

**LAKE ROOSEVELT NATIONAL RECREATION AREA,
WASHINGTON**

_____ WATER RESOURCES SCOPING REPORT

Jon L. Riedel

Technical Report NPS/NRWRD/NRTR-97/107



**National Park Service - Department of the Interior
Fort Collins - Denver - Washington**

United States Department of the Interior • National Park Service

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March 1997

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United States Department of the Interior
National Park Service

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EXECUTIVE SUMMARY

National Park Service (NPS) management of Lake Roosevelt National Recreation Area was established in 1946 under the terms of the Tri-Party Agreement with Bureau of Indian Affairs and the Bureau of Reclamation. This agreement was replaced in 1990 by the Lake Roosevelt Cooperative Management Agreement, which added the Colville and Spokane tribes to the previous three management agencies. These parties provide leadership for management of the water resources with a number of other county, state and federal agencies.

Areas within Lake Roosevelt National Recreation Area (NRA) acquired by the Bureau of Reclamation before 1940 were under concurrent jurisdictional authority of several local, state and federal agencies. Subsequent additions to the Recreation Area were to be under proprietary jurisdiction. The NPS currently manages approximately 60,000 acres at Lake Roosevelt NRA, including approximately 58% of the full-pool reservoir area. This represents a small fraction of the Lake Roosevelt watershed_ at its downstream end.

Land use within the watershed includes agriculture, forestry and mining. Manufacturing is dominated by minerals refinement and wood fiber products industries. Population in the U.S. portion of the watershed increased 30% between 1940 and 1990, while visitor use of the NRA increased from 250,000 in 1965 to more than 1.5 million in 1990. There are approximately 45 visitor use facilities owned by the NPS along the reservoir shoreline, including marinas, campgrounds, and boat launches.

Water resources at Lake Roosevelt NRA focused on Lake Roosevelt, the sixth largest reservoir in the United States. Impounded by Grand Coulee Dam, Lake Roosevelt inundates 151 miles of the former Columbia River and lower Spokane River flood plains in northeastern Washington. In the dry environment surrounding the reservoir, groundwater and surface water from the mouths of tributary streams are also valuable water resources within the unit.

Many issues surround the use of the varied and complex water resources at Lake Roosevelt NRA. Overriding water resource issues are interagency management, and lack of water resource professionals on staff. The size and varied political landscape of this watershed, combined with concurrent jurisdictional authority, make it difficult for the NPS to take an active role in management of water resources. This situation is exacerbated by the fact that NPS currently has no staff with expertise specifically in water resource management.

Foremost among water resource issues is concern for the water quality in Lake Roosevelt. This body of water is classified as AA (extraordinary) by the Washington Department of Ecology. In the mid-1980's, however, U.S. EPA and other agencies detected high levels of lead, zinc, cadmium and arsenic in fish tissue. The primary point sources for the heavy metal pollution were the slag and sewer discharge at the COMINCO lead and zinc processing plant in Trail, British Columbia. In the late 1980's, Canadian researchers also discovered high concentrations of chlorinated organic compounds in Lake Roosevelt fish. The main point source for dioxin and furan was the CELGAR paper mill near Castlegar B.C, which began operation in 1961.

Improvements in these plants over the past 10 years have drastically reduced the amount of pollution dumped into the Columbia River. Dioxin or furan is no longer detectable in the effluent from the CELGAR plant, and COMINCO has decreased the amount of heavy-metal bearing slag dumped from approximately 400 tons/day to less than 5 tons/day, and is scheduled to eliminate discharge in mid-1997. Nonetheless, vast quantities of the previously released pollutants likely remain in sediments at the bottom of Lake Roosevelt, and these industries continue to discharge pollutants, presenting a long-term challenge to water quality management.

Bacteriological pollution of the reservoir waters is a continuing concern. The State Department of Ecology and County Health officials have taken the lead in monitoring bacteriological pollution at swimming areas. These monitoring efforts are sporadic and inconsistent, owing to limited budgets and the belief that low retention time of water in the reservoir reduces the threat of bacteriological contamination.

In the semi-arid climate adjacent to this unit, the NPS and its neighbors rely on groundwater for domestic use at campgrounds, picnic areas, marinas and other developments. The NPS maintains 20 wells within the unit. These wells vary in depth and water quality, and all have either iodine or chlorine treatment systems. Developments near Fort Spokane threaten the groundwater at the site, which the NPS relies on for visitor and administrative use.

Land use in and near the unit are a concern to water quality and aquatic resources as non-point sources of pollution. The NPS currently has authorized 155 special use permits for private developments, including vacation cabins, docks, buoys, water delivery systems and agricultural activities such as grazing. Land use in the majority of the watershed is beyond the NPS control, although the tribes and conservation districts in the county have made strides toward managing land use in parts of the watershed.

Reservoir bank erosion threatens park resources and facilities at hundreds of locations along the 435 miles of shoreline managed by the NPS. Many erosion sites are huge landslides that involve tens of thousands of cubic yards of displaced shoreline sediments. These landslides can happen suddenly and are known to occasionally create large waves as they enter the reservoir. The landslides are controlled in-part by the size and rate of annual reduction in the reservoir elevation. Risk of landslides is a moderate concern for 30-50 ft drawdowns, and a major concern for drawdowns of more than 50 ft. Rates of drawdown in excess of 1.5-2 ft/day are also believed to accentuate occurrence of landslides. Bureau of Reclamation management of reservoir levels has attempted to avoid these conditions for the past 20 years. Natural variation in runoff and competing demands for water and reservoir capacity make managing reservoir levels difficult.

Water pollution and reservoir operation for flood control, irrigation, and enhancing anadromous fish runs on the lower Columbia River System, impact and limit ecological development in the reservoir. Low retention time of water in the reservoir due to large inflow is believed to limit plankton growth, which is the basis for the entire reservoir ecosystem. Drawdowns also negatively impact several non-native popular game fish species. Several introduced species, including Eurasian milfoil, are a growing ecological concern. Concentrations of heavy metal

and organochlorine pollutants remain high in predator and bottom-feeding fish. Other important water resource issues include the need for emergency response planning and baseline resource inventories (wetlands).

This report recommends that the NPS staff at least one full-time water resource management position at Lake Roosevelt NRA before proceeding with development of a Water Resource Management Plan. If the NPS is unable to staff this position, it is recommended that the issue statements provided in this report be used to develop project statements for inclusion in the existing park Resource Management Plan.

INTRODUCTION

Water is a significant resource in units of the National Park Service (NPS), whether in the support of natural systems or providing for visitor enjoyment and use. The NPS strives to perpetuate surface and groundwaters as integral ecosystem components by attempting to maintain the health of aquatic ecosystems in accordance with all applicable laws and regulations. Water resources planning activities are, therefore, essential components of park resource management.

This Water Resources Scoping report focuses on current water resource conditions and issues facing the NPS at the Lake Roosevelt National Recreation Area, Washington, formerly known as Coulee Dam National Recreation Area. The objective of this report is to provide park managers with an up-to-date assessment of existing hydrologic information and water resource issues, so that they are better able to address these issues, where appropriate.

The information in this report has been collected from a variety of sources including a thorough review of NPS files, interviews with local and regional water resources professionals, and contacts with appropriate regulatory agencies and adjacent land managers.

EXISTING RESOURCE CONDITION

Existing condition of the water resources of Lake Roosevelt National Recreation Area is a result of the diverse uses of the watershed and Franklin D. Roosevelt Lake (commonly called Lake Roosevelt). Industry, recreation, agriculture and municipalities all rely on and effect Lake Roosevelt National Recreation Area's water resources. Understanding these effects is complicated by the concurrent jurisdictional authority of tribal, international, federal, state, public and private interests managing the watershed.

LOCATION AND MANAGEMENT HISTORY

Lake Roosevelt National Recreation Area is located in northeastern Washington State, along the mainstem of the Columbia River (Figure 1). Coulee Dam was completed in 1942 and is operated by the Bureau of Reclamation in Coulee Dam, Washington. The Grand Coulee Hydroelectric Project is part of the Columbia Basin Project. The dam creates 133 mile-long Lake Roosevelt, which includes 29 mile-long Spokane Arm. At 81,389 acres, it is the sixth largest reservoir in the U.S. and the focus of the Lake Roosevelt National Recreation Area.

The Lake Roosevelt watershed is managed by a diverse collection of public agencies and private interests in the United States and Canada. In the U.S. the watershed includes parts of the Spokane and Colville Reservations, Colville National Forest, and Lincoln, Stevens and Ferry counties (Figure 2). The 1909 Boundary Waters Treaty between the U.S. and Canada gave the International Joint Commission binding authority with respect to water flow and water level on

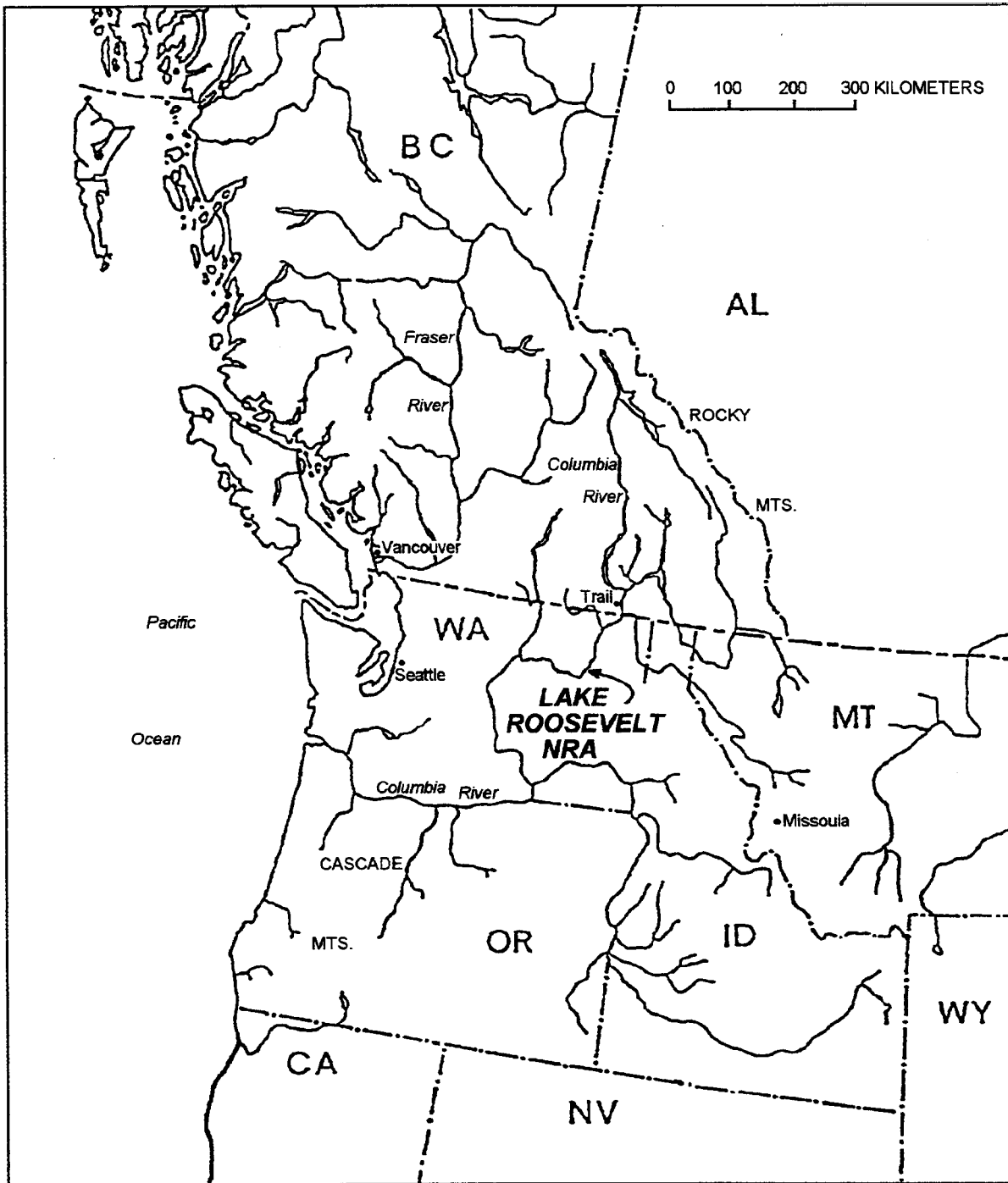


FIGURE 1. Regional Location of Lake Roosevelt National Recreation Area.

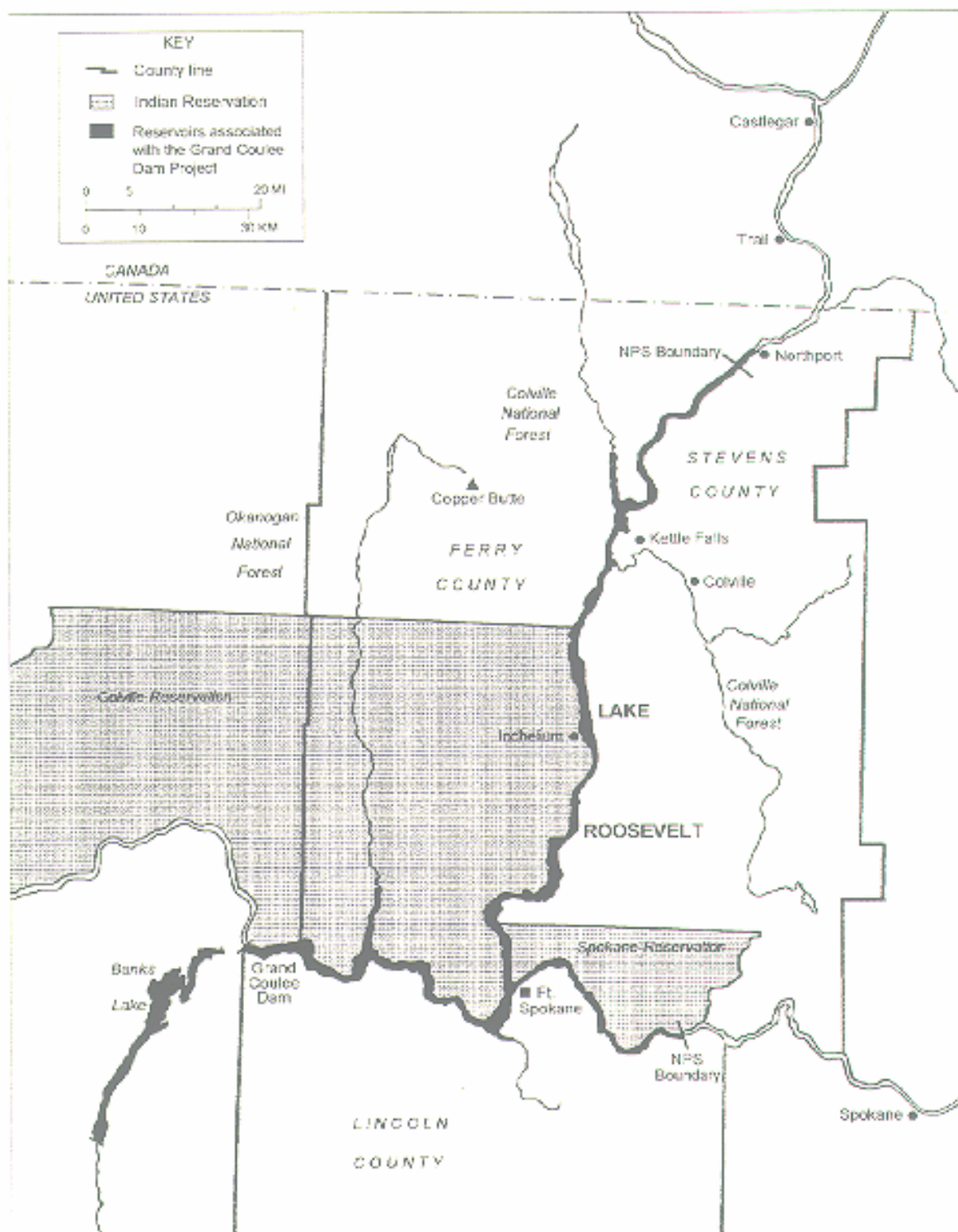


FIGURE 2. Political Boundaries in and near Lake Roosevelt National Recreation Area. (See Fig.3 for Lake Roosevelt NRA Boundary.)

the Columbia River (Table 1). Their jurisdiction is limited to an advisory capacity in regards to water quality issues.

The NPS manages a very small fraction of the upper Columbia River watershed at its downstream end, and only approximately 58% of the reservoir's surface area (Figure 3). In total, the NPS manages 60,374 acres, including 47,438 acres of reservoir, shorelines and stream mouths. The 540 acre Fort Spokane Military Reservation was transferred to the NPS in 1960. The NPS and Spokane Tribe have an ongoing dispute over authority to manage the portion of the Lake Roosevelt that floods the lower Spokane River (Spokane Arm). Section 1.0. of the Lake Roosevelt Cooperative Management Agreement states, "...there exists a dispute on the extent of the Spokane Indian Reservation on the Spokane River Arm of Lake Roosevelt..."

Concurrent jurisdiction of lands acquired by the Bureau of Reclamation prior to 1940 was agreed to by state, federal and local authorities. Subsequent acquisitions of land were to be under proprietary jurisdiction. Regulations developed by the State of Washington Department of Ecology (Washington Department of Ecology) are used to manage lands by federal agencies in Washington, including water quality issues on NPS land. The Washington Department of Ecology's jurisdiction does not, however, extend to tribal lands.

Passage of the Park, Parkway and Recreation Area Study Act by Congress in 1936 established Coulee Dam recreation area. NPS management began in 1946, when Congress authorized the NPS to administer the area under the basic jurisdiction of other federal agencies through cooperative agreements. A Tri-Party Agreement between the Bureau of Reclamation, NPS and Bureau of Indian Affairs was signed by the Secretary of the Interior on December 18th, 1946. This agreement provided guidance to NPS managers for 44 years. Congress has not passed specific enabling legislation or provided more detailed management direction for this unit of the NPS.

The Lake Roosevelt Cooperative Management Agreement, signed in 1990 by the Secretary of Interior, replaced the Tri-Party Agreement. The five major parties that are named in the 1990 Cooperative Agreement are the NPS, Bureau of Reclamation, Bureau of Indian Affairs, the Colville Confederated Tribes, and the Spokane Tribe of Indians. This agreement confirmed Lake Roosevelt National Recreation Area as a unit of the National Park System, subject to all NPS laws, regulations, policies and guidelines. Other agencies interested in the management of this resource are listed in Table 2.

The Lake Roosevelt Coordinating Committee is represented by the five main parties of the Cooperative Management Agreement (Figure 4). The Lake Roosevelt Coordinating Committee, established under Section E of the Lake Roosevelt Cooperative Management Agreement, was organized to allow the respective managers of the Lake Roosevelt Management Area to work in a way consistent with the Management Agreement. The Lake Roosevelt Forum was created in 1990 as a public involvement group to provide a neutral arena for all interested parties

TABLE 1. Timeline of Land Use Actions Related to Lake Roosevelt National Recreation Area.

DATE	ACTION
1909	Boundary Waters Treaty signed; gives International Joint Commission ultimate authority over level and flow of the Columbia River
1936	Passage of the Park, Parkway and Recreation Area Study Act
1942	Coulee Dam completed; creates Franklin D. Roosevelt Lake (reservoir)
1946	Congress authorizes NPS to administer area of Coulee Dam NRA
1946	Tri-Party Agreement between Bureau of Reclamation, National Park Service and Bureau of Indian Affairs
1960	Fort Spokane Military Reservation transferred to NPS
1962	Executive Order 11017 signed; establishes a Recreation Advisory Council to coordinate federal government policy regarding NRA's
1980	Coulee Dam General Management Plan completed
1980	Northwest Electric Power and Planning Conservation Act signed; mandates Bonneville Power Administration to provide for fish and wildlife mitigation
1990	Lake Roosevelt Cooperative Management Agreement signed; replaces 1946 Tri-Party Agreement and establishes Lake Roosevelt Coordinating Committee
1992	Statement for management of Coulee Dam, summarizes numerous planning documents (NPS)
1993	NPS proposes to become an equal representative for fish and wildlife on the Northwest Power Planning Council

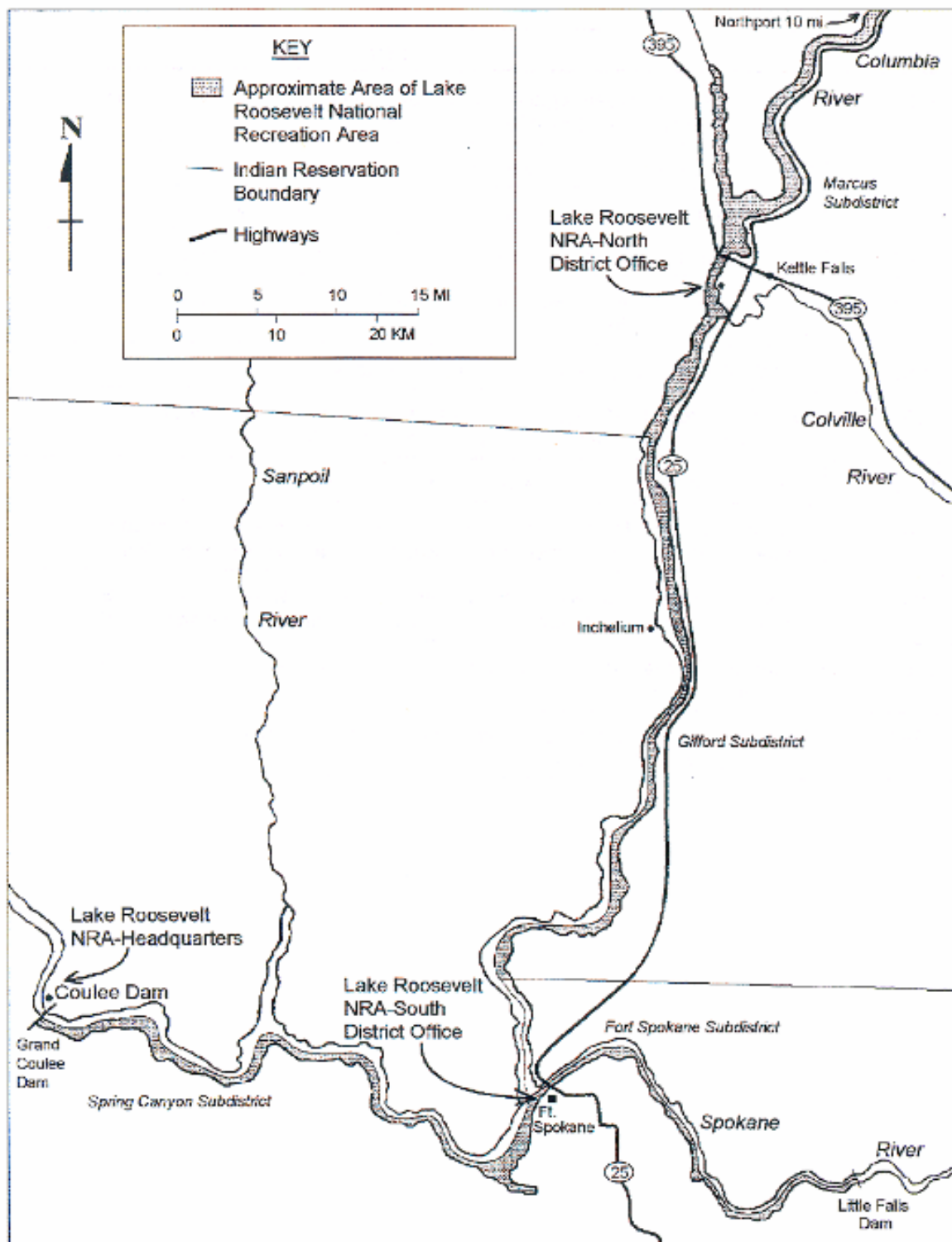


FIGURE 3. Lake Roosevelt National Recreation Area Administrative Districts and Offices.

TABLE 2. Agencies, Groups and Parties Interested in Management of Lake Roosevelt Not Included in the 1990 Lake Roosevelt Cooperative Management Agreement (Source: Bucy and Funk, 1996).

<u>FEDERAL</u>	Bonneville Power Administration Bureau of Land Management Environmental Protection Agency National Marine Fisheries Service Natural Resource Conservation Service U.S. Army Corps of Engineers	U.S. Fish and Wildlife Service U.S. Forest Service U.S. Geological Survey Northwest Power Planning Council Canada Department of Fisheries and Oceans Environment Canada
	<u>STATE/PROVINCIAL</u> British Columbia Ministry of Health British Columbia Ministry of Environment, Land and Parks State of Washington Department of Health	State of Washington Department of Ecology State of Washington Department of Fish and Wildlife
<u>LOCAL</u>	(counties, towns, conservation districts, etc.) Stevens County Lincoln County Ferry County	Okanogan County Grant County
<u>CITIZEN INTERESTS</u>	Citizens for a Clean Columbia Kettle Falls Walleye Club Lake Roosevelt Water Quality Council Lake Roosevelt Forum Lake Roosevelt Property Owners Association	National Parks and Conservation Association Washington Cattlemen's Association Washington Association of Wheat Growers Spokane Walleye Club
<u>INDUSTRIAL INTERESTS</u>	Cominco, Trail, British Columbia Celgar Pulp and Paper, Trail, British Columbia	Washington Water Power Company, Kettle Falls

LAKE ROOSEVELT FORUM
(Citizen's advisory group)
Focus: Public involvement in land management, water quality,
resource management and emergency services issues.

LAKE ROOSEVELT COORDINATING COMMITTEE
(As established by the Lake Roosevelt Cooperative Management Agreement)
National Park Service, Bureau of Reclamation, Bureau of Indian Affairs, Colville Confederated Tribe, Spokane Tribe

LAKE ROOSEVELT WATER QUALITY COUNCIL
Focus: Research and restore the water quality and aquatic resources of Lake Roosevelt to protect it for future generations.

LAKE ROOSEVELT TECHNICAL COMMITTEE
Focus: Develops project workplans, secures contractors and reviews and interprets technical reports.
-National Park Service
-Bureau of Reclamation
-Colville Confederated Tribe -Spokane Tribe
-U.S. Fish and Wildlife Service -Environmental Protection Agency -
Natural Resources Conservation Service
-U.S. Geological Survey
-Upper Columbia River Tribes -Regional Health Departments -Eastern Washington University
-Water Research Center at Washington State University

LAKE ROOSEVELT MANAGEMENT COMMITTEE
Focus: Sets goals and priorities and makes funding requests. -
Superintendent of Coulee Dam NRA
-Colville and Spokane Tribal Representatives
-Two County Commissioners
-State of Washington Department of Fish and Wildlife

FIGURE 4. Organizational Chart for the Lake Roosevelt Cooperative Management Agreement.

throughout the region to meet, learn about proposed activities early in the planning process, and seek common ground on which to promote a coordinated vision of Lake Roosevelt and its watershed.

Initially, forums were started by citizens via the Partnership for Rural Improvement and the Washington State University Cooperative Extension. The Lake Roosevelt Forum was subsequently successful in competing for a 6-year grant from the Northwest Area Foundation. Its mission is "...to establish a dialogue based on trust and respect for all views, by seeking common ways to protect and preserve the quality of life as they relate to the lake and the economics of the region."

The Lake Roosevelt Water Quality Council was formed to coordinate and manage reservoir-related research funded by the Environmental Protection Agency (EPA) (Figure 4). The goal of the Council is to investigate, restore and protect the water quality and aquatic resources of Lake Roosevelt for future generations. Funding for the Lake Roosevelt Water Quality Council's activities was provided by a five-year grant from the U.S. Environmental Protection Agency's Clean Lakes Program (expired 1995). This grant was administered by the Washington Department of Ecology and Washington State University.

Goals, priorities and funding requests for the Lake Roosevelt Water Quality Council are set by its Management Committee. Stated goals include:

- 1) Ensure enforcement of water quality laws;
- 2) Identify, prioritize and implement new measures to protect water quality;
- 3) Establish and maintain a water quality database and monitoring network;
- 4) Develop and maintain a citizen education action program; and
- 5) Undertake investigations and studies as required to carry out the mission statement.

The Lake Roosevelt Management Committee includes many agencies (county, state and federal) and citizen interest groups (see Figure 4). The current co-chairs are the Spokane Tribal representative and a County Commissioner. The Lake Roosevelt Water Quality Council also has a Technical Committee that develops project work plans, secures contractors, and reviews and interprets technical reports. NPS involvement in these multi-agency management committees is limited by the lack of enabling legislation, an understaffed resource management division and a lack of consistent funding sources.

The Northwest Electric Power Planning and Conservation Act (1980) mandated Bonneville Power Administration to use its funds to provide fish and wildlife mitigation for federal dam projects on the Columbia River, including Grand Coulee Dam. In response, a consortium of agencies initiated the Columbia Basin Management Plan, which calls for a multi-phased program to mitigate the impacts of the dams and reservoirs on fish and wildlife (Lake Roosevelt NRA, 1993). The NPS submitted a proposal to the Northwest Power Planning Council for funds to conduct wildlife habitat research on 3500 acres of riparian habitat on the lower Kettle River.

This request was not funded, in part, because the NPS role as a fish and wildlife agency is unclear in recent interpretations of the Northwest Power Act by the Northwest Power Planning Council. The Act lists the NPS under the land management agency category, and it has been noted that the NPS is not a member of the Washington Wildlife Coalition (Lake Roosevelt NRA, 1996). This interpretation limits NPS involvement funding proposals and in the 10-year Columbia Basin Management Plan (for anadromous fish). In 1993, the NPS sought consideration as a fish and wildlife management agency with the Northwest Power Planning Council, but was denied.

The NPS management of Lake Roosevelt National Recreation Area is also guided by Executive Order 11017 (1962), which establishes a Recreation Advisory Council to coordinate federal government policy. The Council's adopted policy identifies National Recreation Areas as "offering a quality of recreational experience which transcends that normally associated with areas provided by state and local governments." The Council's Circular Number 1 describes the dominant/primary use of National Recreation Areas as "outdoor recreation."

The National Recreation Area's General Management Plan, completed in 1980, (update beginning 1/97), states that a systematic water quality monitoring program will be developed and human uses of the area will be managed to ensure that the Washington Department of Ecology Class AA water quality of Lake Roosevelt is maintained (NPS, 1980).

In the General Management Plan, the NPS also identifies five management zones within the National Recreation Area. These include Reservoir Recreation, Indian, Park Development, Historic, and Natural zones. The Reservoir Recreation zone includes most of the reservoir, where navigation markers, marinas and other facilities assist the visitor in enjoying Lake Roosevelt. The Indian zone is not part of the National Recreation Area, and includes lands managed by the Colville and Spokane Tribes. Historic zones include Fort Spokane and Kettle Falls Historic District. Park Development zones include those lands used for high density recreation. All NPS developments are within this zone. Natural zones include two subzones: Natural Environment and Environmental Protection. The Natural Environment zone prohibits future high-use development and includes lands where there is currently little to no development. The Environmental Protection zone includes three outstanding natural features within the unit. These are Whitestone Rock, Little Dalles and Hawk Creek Falls. This zone is managed to keep physical development to an absolute minimum.

Lake Roosevelt National Recreation Area is administratively organized into two districts and four subdistricts (Figure 3). The South District stretches from Coulee Dam to Little Falls Dam on the Spokane River, and includes the Spring Canyon and Fort Spokane subdistricts. The North District includes the region north from Fort Spokane to Onion Creek, and includes the Gifford and Marcus subdistricts. Headquarters is located in the town of Coulee Dam.

WATERSHEDS AND HYDROGRAPHY

The Lake Roosevelt watershed drains approximately 44,969 square miles, 88 % of which is in Canada (Figure 5)(Cornett, 1994; U.S. Dept. of Energy et al., 1991). Headwaters rise from Columbia Lake in British Columbia, and are fed by snowfields and glaciers located at elevations above 11,000 ft on the west flank of the Rocky Mountains. Other watershed divides include the Monashee Mountains, the Okanogan Highlands, the Clearwater Mountains, the Palouse/Spokane Divide and the obscure Crab Creek/Columbia River divide.

Mean annual precipitation at Grand Coulee Dam is 10.7 inches, while at Colville it is 17.4 inches. High rates of evaporation reduce effective precipitation at Colville to 8.8 inches annually (U.S. Dept. of Commerce, 1991). Precipitation falls mainly in the winter as snow over most of the Lake Roosevelt watershed. In 1952, snow depth reached 39 inches on Reed Terrace on the western shore of the reservoir near Kettle Falls (Jones et al., 1961). More than half of all runoff occurs in the spring and early summer as snow melts throughout the watershed. The climate of the region is also characterized by low precipitation and lower runoff in late summer and early fall.

Spring runoff typically begins in April, and peaks in May or June. Mean June discharge of the Columbia River at the international boundary is 141,150 cubic feet/second (cfs), while mean March discharge is 42,345 cfs (British Columbia Ministry of Environment, 1979). Discharge of the river at the international boundary before dam construction upstream, reached lows of 14,000 cfs to flood flows over 500,000 cfs (U.S. Department of Energy, 1991). Runoff in the watershed is measured in the U.S. at gaging stations on the Columbia River (International Boundary and near Northport), Kettle River (at International Boundary), Colville River (near Kettle Falls) and the Spokane River (in Spokane and at Post Falls). Smaller tributaries (Little Spokane River, Chamokane Creek and Blue Creek) are also gaged.

Two of the upper Columbia River's largest tributaries, the Kootenay River and Pend Oreille River, join the Columbia just north of the international boundary. Each is responsible for approximately 1/3 the combined flow at the merger of these tributaries. Outflow from the Kootenay is sufficient to cause hydraulic ponding of the Columbia River upstream to Hugh Keenleyside Dam. Upon completion in the mid-1960s, Hugh Keenleyside Dam generally reduced spring flood flow and increased low winter flows on the short reach of the Columbia River above Lake Roosevelt.

Smaller tributaries that enter Lake Roosevelt in the U.S. include the Colville (1% of flow), Spokane (7%), Kettle (3%) and Sanpoil rivers (1%) (Beckman et al., 1985). The NPS manages approximately 25 linear miles of streams at the lower end of these rivers. Characteristics of U.S. watersheds draining into Lake Roosevelt are given in Table 3. Additional watershed information is available in Stevens County, U.S. EPA (1993) and Nelson (1973).

Wetlands have been mapped for Lake Roosevelt National Recreation Area at 1:24,000 scale by the National Wetlands Inventory Program (U.S. Fish and Wildlife Service, 1987). Palustrine

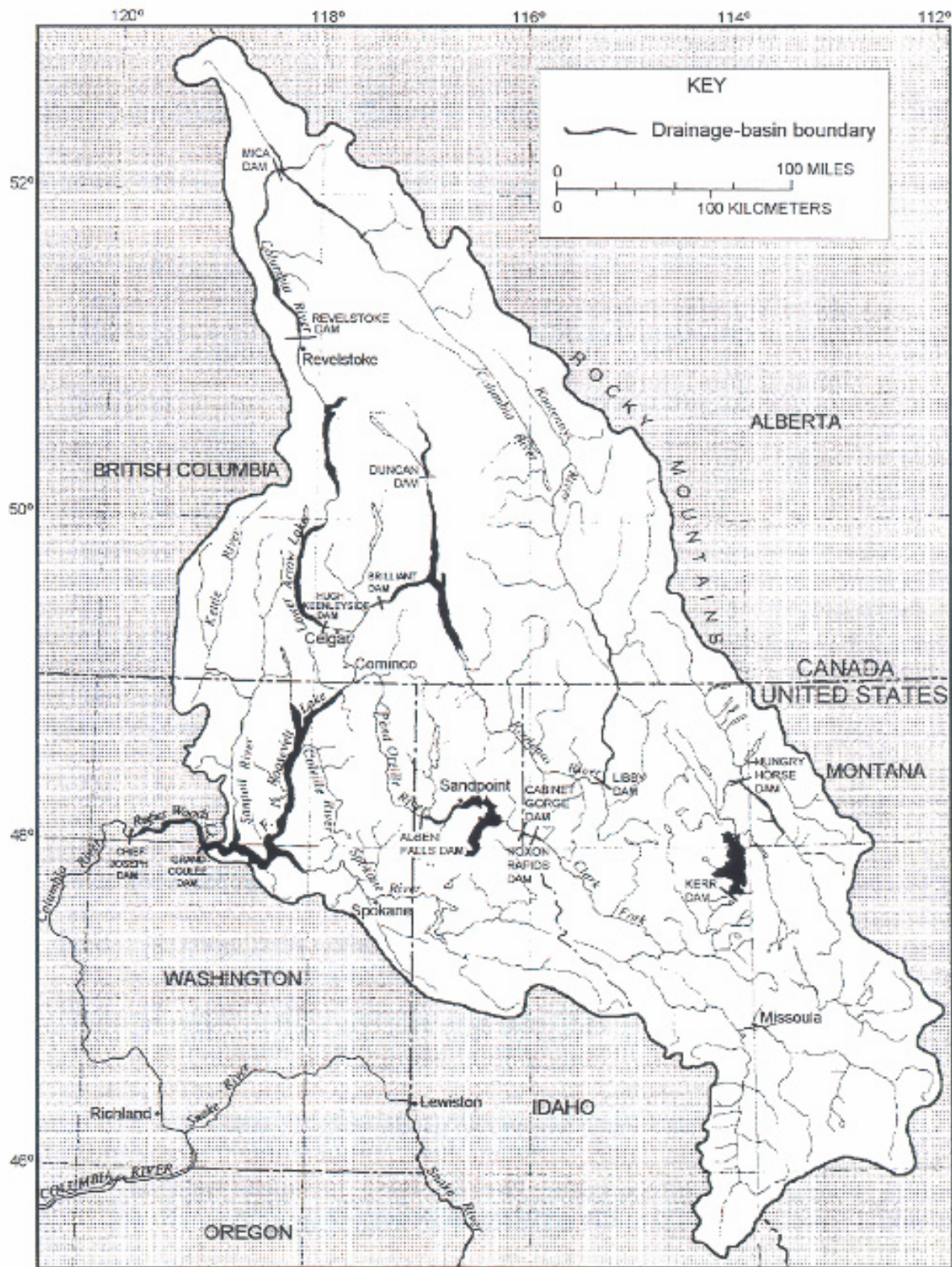


FIGURE 5. Franklin D. Roosevelt Lake Watershed (Source: Bortelson et al., 1994).

wetlands at Lake Roosevelt National Recreation Area total 15,000 acres. The two largest wetlands are located at the mouths of the Kettle and Colville rivers. The Tri-County Wetlands Study for Stevens, Ferry and Pend Oreille counties has wetlands information digitized, and the Agricultural Stabilization and Conservation Service has 1:8000 scale air photos with U.S. Department of Agriculture jurisdictional wetlands outlined (Stevens County and U.S. EPA, 1993).

TABLE 3. Characteristics of *Eight U.S. Watersheds Draining into Lake Roosevelt* (Source: Stevens County and U.S. Environmental Protection Agency, 1993).

WATERSHED	AREA (acres)	DESCRIPTION
Chamokane Creek	140,000	-southern Stevens County -includes a portion of the Spokane Reservation
Colville River	650,000	-Stevens County -includes cities of Colville and Chewelah and a portion of Kettle Falls -approximately 75% of the county's population resides in this watershed
East Columbia	300,000	-western Stevens County along Lake Roosevelt -runs south from the Kettle Falls area to the Spokane River -predominantly agricultural and forest land
Kettle River	600,000	-northern Stevens, Ferry and Okanogan Counties -includes the towns of Curlew and Danville -predominantly federally administered land
Lincoln	330,000	-northern Lincoln County, -northern boundary formed by Columbia River and Spokane River -contains cities of Reardon, Davenport and Creston -runs from Grand Coulee Dam east to Long Lake Dam -land use is mostly agricultural
North Columbia	300,000	-northern Stevens County from Kettle Falls to the Canadian border -includes the city of Kettle Falls and the towns of Marcus and Northport
Sanpoil River	740,000	-Ferry and Okanogan counties -southern portion of the watershed is comprised of the Colville Reservation -includes the city of Republic
West Columbia	520,000	-eastern Ferry County -southern portion of watershed is comprised of the Colville Reservation -eastern boundary is Lake Roosevelt

GEOLOGY AND SOILS

The Columbia River watershed spans several physiographic provinces. In Canada, the watershed is largely within the Columbia, Rocky and numerous other mountain provinces (McKee, 1972). These mountains are composed of a wide range of igneous, metamorphic and sedimentary rocks. Mineral deposits of lead, zinc and copper are found throughout the upper watershed in British Columbia.

In the U.S., the Columbia cuts a course due south across the Okanogan Highlands Province for 75 miles, following the southern extension of the Selkirk Trench. Low mountain ranges trend north-south along upper Lake Roosevelt. They are composed primarily of pre-Tertiary metamorphic rocks, Paleozoic sedimentary rocks, and small outcrops of Mesozoic granites east of Lake Roosevelt. Beneath the upper reach of the reservoir are Triassic/Permian metasedimentary rocks, while south of Kettle Falls Carboniferous/Ordovician metasedimentary and metacarbonate rocks dominate. The middle reach of the reservoir curves from southeast to west around Tertiary/Cretaceous granitic bedrock before turning due west. The lower stretch of the reservoir follows the boundary between Tertiary granites, with thick accumulations of Quaternary deposits to the north and basalt flows of the Columbia Plateau province to the south. More detailed information on bedrock geology is available from the Spokane Tribe's GIS, and from 1:100,000 scale maps published by the State of Washington Department of Natural Resources, Division of Geology and Earth Resources in Olympia.

Forest vegetation dominates in the mountain portions of the upper watershed, and includes ponderosa pine, western larch and Douglas fir. On the Columbia Plateau, semi-arid shrub steppe vegetation dominates, including grasses on wetter sites and rabbit brush and sage on drier sites. Fire is an important ecological process in the ponderosa pine and other coniferous communities. In the summer of 1991, a fire swept through a large part of the Colville River watershed.

Glaciers have played a large role in the development of the Lake Roosevelt National Recreation Area landscape. Lobes of continental glaciers moved down the Okanogan and Columbia Rivers numerous times during the past million or so years. Glacier-caused erosion of the bedrock dramatically widened and deepened the Columbia and its tributary valleys. Further erosion was caused by huge torrents of water flowing from glacial ice dammed Lake Missoula in the Pend Oreille tributary valley (Bretz, 1969). These floods waters swept down the Columbia and Grand Coulee numerous times during the past ice ages, and created the geography of this area (Waitt, 1980; Atwater, 1986).

Approximately 16,000 and 13,000 years ago during the last ice age, the Okanogan Lobe blocked the Columbia River, creating huge Glacial Lake Columbia in the valley now occupied by Lake Roosevelt. Sand and silt deposited in this lake, particularly at the mouths of its tributaries, created massive fills over 1,000 ft thick (Pardee, 1918; Flint, 1935; Flint and Irwin, 1939). Terraces at 2350 ft, 1950 ft and 1800 ft mark the elevation of three such lakes created by Okanogan Lobe ice dams (Anderson, 1969). The Columbia Lobe of the continental glacier,

which reached its southernmost extent at the mouth of the Spokane River, left relatively thin deposits of gravel and boulders in various places along present day Lake Roosevelt. Following the retreat of the Okanogan Lobe and the demise of Glacial Lake Columbia 13,000 years ago, the Columbia River and its tributaries began cutting into the thick ice age deposits, leaving their surfaces standing as terraces high above the present reservoir elevation. Slopes descending the terrace tops to the former floodplain drop as much as 1,000 feet in elevation. These steep slopes are subject to occasional landslides since the last ice age 10,000 years ago (Jones et al., 1961). A 1906 landslide near Ninemile Creek was large enough to temporarily block the Columbia River.

Eruptions from distant volcanoes located several hundred miles away in the Cascade Range, have influenced the geology and soils of the watershed. The 1980 eruption of Mount St. Helens caused a huge amount of volcanic ash to wash into the Spokane River. This ash eventually reached Lake Roosevelt and created a distinct plume in Spokane Arm. Deposits from eruptions of Mount Mazama (Crater Lake) and Glacier Peak have also spread ash over the area.

Broad classification of soils in the upper Columbia watershed reflect the geology and climate of the mountain and plateau physiographic provinces. Soil orders found in the mountainous areas are primarily entisols, while aridosols dominate the plateau. Detailed large scale soil surveys have been prepared by the Natural Resources Conservation Service (formerly the Soil Conservation Service) for the U.S. portion of the watershed, including Ferry (1979), Stevens (1980) and Lincoln (1981) counties. These surveys provide detail on soil types and distribution as well as information on land use, erosion potential and engineering properties. Additional soil and surficial geology information is available for Colville National Forest, and for certain private, state, county and tribal lands within the watershed.

Sediment Erosion and Deposition

Approximately 10% of the shorelines along Lake Roosevelt are composed of bedrock, while the remaining 90% are composed of thick ice age deposits (Jones et al., 1961). Bedrock shorelines, found mainly on the south shore of the lower reach and in Spokane Arm, are generally more stable than those composed of silt and sand. However, at least one landslide from the Columbia Plateau basalt has reached Lake Roosevelt (Jones et al., 1961). Terrace deposits are particularly extensive on parts of the north shore of the lower reach of the reservoir near the Sanpoil River, and in the middle reach near Ninemile Creek Cedonia, and the mouths of the Kettle and Colville Rivers. These terrace slopes have failed at hundreds of sites over the last 54 years (Jones et al., 1961; Schuster, 1979).

Jones and others (1961) identify four types of landslides, including slump earth flow, slip-off slope, multiple alcove and mudflow. The slip-off slope landslides occur in terraces composed primarily of sand and gravel deposits. These failures are one-time events, are shallow, and involve little overall displacement of sediment. Larger earth flows, mudflows and multiple alcove flows occur in finer-grained silt and clay deposits, are bigger and extend over longer periods of time than slip-off slope movements.

Landslides are believed to be caused primarily by rapid reservoir drawdown and reservoir levels below a 1240 ft elevation (Jones et al., 1961). Positive pore-water pressure in the bank sediments, wave undercutting, snowmelt, perched groundwater, and precipitation all play a role in the landslide process. Of 500 landslides studied between 1942 and 1953, 49% occurred during the first two years the valley was flooded (Figure 6). Large reservoir drawdowns in 1944 (30 ft), 1952 (60 ft) and 1953 (60 ft), accounted for 30% more of the total number of landslides (Jones et al., 1961). The addition of a third generating plant at the dam in conjunction with the large drawdowns were related to greater landslide frequency between 1969-74 (Schuster, 1979). The total volume of all landslides was estimated at 50-100 million cubic yards at 24 major landslide areas. Full pool elevation is 1289 ft, while typical drawdown is in the range of 30 ft (1260 ft). Risk of landslides is a minor concern for a 30 ft drawdown, a moderate concern for a 30-50 ft (1260-1240 ft) drawdowns, and a major concern for drawdowns greater than 50 ft. The Bureau of Reclamation is attempting to minimize shoreline landslides during rapid drawdown of the reservoir. Their goal is to not lower the reservoir elevation by more than 1.5 ft/day, or 3 ft/2 days.

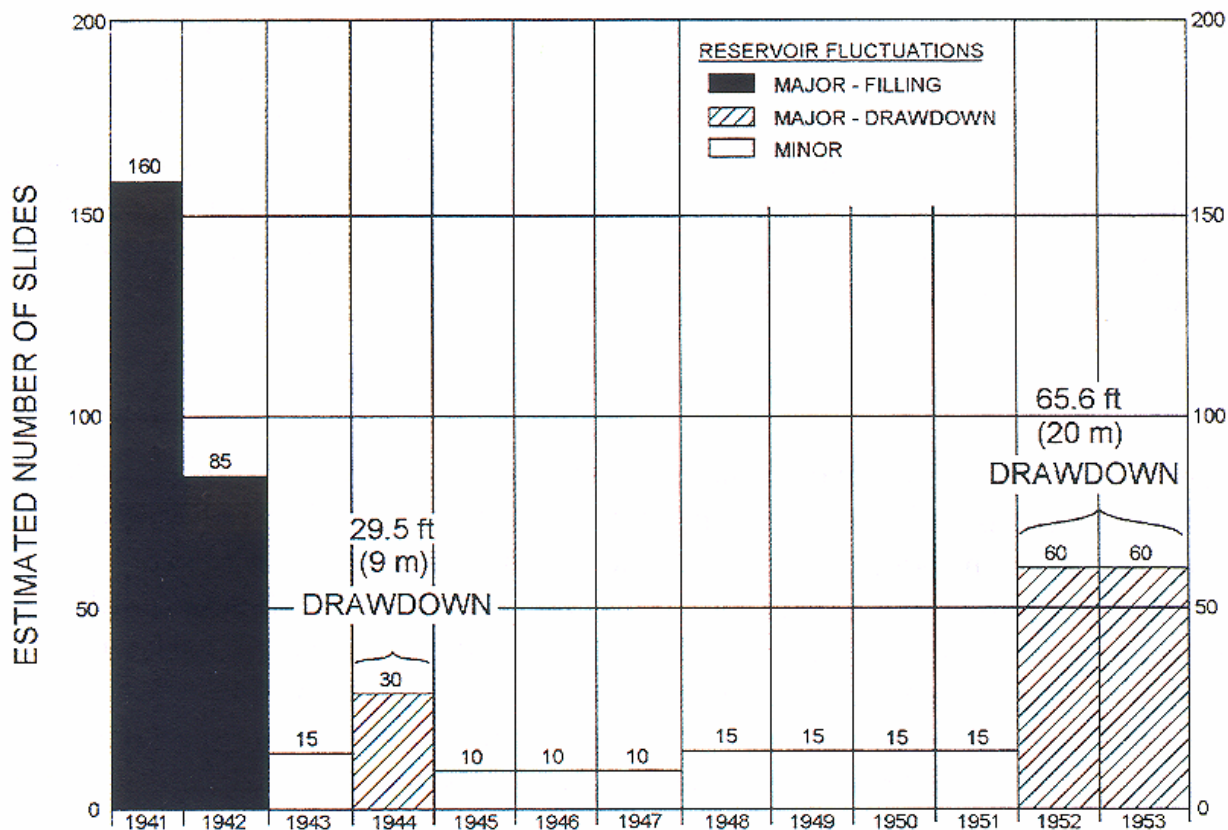


FIGURE 6. Frequency of Landslides along Lake Roosevelt Between 1941 and 1953 (Source: Jones et al., 1961).

A small number of other slope failures are related to land use. For example, in winter 1995, two large slope failures occurred at Lincoln Mill that were a result of activities by the landowner up

slope from the NPS managed public land. A brief history indicates that two small ravines were filled earlier in the century with wood waste materials from the forest products mill at Lincoln. These wood wastes would periodically ignite due to heat from decomposition, and become a fire hazard. A recent change of ownership prompted the state to require the new owner to mitigate this problem. In the summer of 1994, the new owner excavated the site and removed the wood waste, filled the ravines with sand, spread the wood waste in a two foot thick layer over the sand, then covered the site with a one foot thick layer of topsoil. Revegetation of the site was incomplete. In February 1995, an early thaw caused two large slope failures to cross and damage public land, and to deposit wood waste and sediment into Lake Roosevelt.

The landslides in and around Lake Roosevelt watershed cause millions of dollars in damage to public and private property, including cultural resources, roads, farms and homes. They also present a considerable safety hazard. For example, a 1952 landslide at Reed Terrace caused the shoreline to retreat nearly 2,000 feet in one day, claiming three roads and considerable agricultural land. This landslide also caused a 65 ft high wave to cross Lake Roosevelt (Jones et al., 1961). Large landslides have and will continue to cause large waves. On nearby Ross Reservoir, shoreline erosion claims 1.5 acres of land/year (Riedel, 1990). Lake Roosevelt has nearly four times the shoreline, larger and more extensive glacial deposits, and higher rates of bank recession due to the massive landslides, than Ross Lake. Therefore, it is estimated that bank erosion claims at least 5 acres/year on Lake Roosevelt.

Sediment from landslides is deposited within the waters of the reservoir at varying depths. Jones and others (1961) discuss transformation of flows into turbidity currents beneath the water surface. Annual drawdowns also prevent equilibrium shoreline configurations from developing on many reservoirs (Lawson, 1985; Riedel, 1990). Jones and others (1961) suggested that most of the reservoir bed sediments found in the mid-and lower reservoir were from bank erosion of glacial deposits.

Slower, more gradual rates of bank recession also threaten campgrounds, trails and other facilities located on lower terraces near the full pool elevation. Wave erosion and freeze-thaw processes are likely to be the primary processes of gradual reservoir shoreline erosion in northern regions and the Pacific Northwest (Lawson, 1985; Riedel, 1990). Surficial processes such as tilling and gullying on shorelines without vegetation, are also important. Vegetation is disturbed by construction of new homes near public land boundaries. Rills can expand to gullies when landowners fail to control site runoff. Much of this problem originates from land occupied by single-family homes and home owner associations.

Much of the natural sediment load of the upper Columbia River and its three main tributaries (Spokane, Kootenay and Pend Oreille) are cut off from Lake Roosevelt by the multitude of dams upstream. The remaining sediment load carried by the Columbia River into Lake Roosevelt, is a fine-grained suspended load. Daily suspended sediment load is estimated at 1,350 tons/day (Miles et al., 1993). The suspended sediment yields of the other major U.S. watersheds range from 10-45 tons/square mile/year (Nelson, 1973). Annual totals for the Columbia and the other tributaries are given in Table 4.

TABLE 4. Annual Suspended Sediment Yields of the Columbia River and Selected Tributaries
(Source: Miles et al., 1993 for Columbia River; others from Nelson, 1973).

RIVER	TONS PER YEAR	TONS PER SQUARE MILE PER YEAR
Columbia	492,750	8
Colville	15,000 - 45,000	15-44
Kettle	18,740	20
Sanpoil	11,560	10

Sediments deposited into the reservoir include gravel, sand and silt located at the mouths of major tributaries and beneath the large landslides. Sediment texture becomes finer-grained with distance from these sources. For example, at Northport, coarse riverine gravel and sand deposits dominate the reservoir bottom in the drawdown zone. At Kettle Falls, sediments deposited in the reservoir are fine-grained lacustrine silts and clays.

In the past, a good portion of the sediment load entering Lake Roosevelt was slag from a smelter operated by COMINCO and located upstream in Trail, B.C. In July 1996, COMINCO drastically curtailed dumping slag, and is now legally permitted to dump up to 4.5 tons/day until mid-1997. According to their monitoring data, only 0.5% of previous levels is still being discharged. This dumping will be completely eliminated when COMINCO's new smelter comes on line in mid-1997. Prior to 1996, and after more than 65 years of COMINCO operation, approximately 8 million tons of this black, sand-sized slag entered the Columbia River. The finer fraction of the slag material can remain suspended in the water column, and form beaches and river bars as far as 30 miles below Trail. It is not currently known what the distribution of the slag deposits is in the reservoir. The coarser fraction of the slag is most likely in the upper reach of the reservoir. Finer grained sediment from the slag and dissolved material has probably been carried into the mid-and lower reaches of Lake Roosevelt.

IMPOUNDMENTS

Nine major reservoirs are located upstream of Lake Roosevelt National Recreation Area on the Columbia and its tributaries, representing 1/3 of all the dams on the river (Figure 5). These dams created Duncan Lake in British Columbia, and Boundary Lake in the U.S., and deepened natural lakes at Arrow and Kootenay lakes in British Columbia and Priest and Pend Oreille lakes in the U.S. Most of these dams, including those on Kootenay and Pend Oreille rivers, are run-of-the-river types that have little storage capacity. In addition, three dams and associated large reservoirs are located on the Spokane River in Idaho and Washington (Figures 5 and 7).

The 1942 closure of 550 ft tall Grand Coulee Dam created Lake Roosevelt in the Columbia River valley. Primary purposes of this project included hydroelectric power generation, irrigation and flood control. Recreational and economic uses of Lake Roosevelt and its resources have added to the diversity of the original reservoir purposes. Grand Coulee Dam is the largest storage structure of 30 dams on the Columbia River. Since most dams downstream are run-of-the-river structures with minimal storage capacity, Grand Coulee Dam plays an important role in many issues along the river as far downstream as Portland, Oregon.

Lake Roosevelt is 133 miles long, and includes the 29 mile-long Spokane Arm. In total, the reservoir covers 81,389 acres, and has a maximum width of 1.9 miles. The reservoir stores 9.4 million acre-feet of water at full pool, and 7.3 million acre-feet at average drawdown of 27 ft below full pool. (Johnson et al., 1989). The reservoir has an average depth of 188 ft, and a maximum depth of 399 ft at Grand Coulee Dam. Lake Roosevelt fills from the north because of the large inflow of Columbia River water. Due to turbulent mixing at the head of the reservoir, no true density-current system is believed to develop (Jaske and Snyder, 1968).

There are three geologically distinct reaches on the reservoir, including the lower reach from the dam to Spokane Arm, a middle reach from Spokane Arm to Marcus Island, and an upper reach from Marcus Island to the end of the reservoir (Figure 7). Ponding effects at drawdown are seen as far upstream as Marcus Island, and during full pool to Northport (Serdar, 1993).

In 1984, approximately 3 million acre-feet of water stored in Lake Roosevelt was used for flushing anadromous fish smolt down the Columbia River. Following federal listing of the Snake River chinook, coho and sockeye salmon as endangered species, the amount of water reserved for flushing was increased to 3.5 million acre-feet. Competing uses of the remaining available water include irrigation, erosion control, and power generation (Bucy and Funk, 1996).

At the heart of many water resource issues, is the operation of Lake Roosevelt. The size and location of Grand Coulee Dam in the middle reaches of the watershed play a key role in the coordinated operation of 14 dams on the mainstem Columbia River. Of particular importance, are the annual retention time of water in the reservoir and annual drawdown elevation. These physical manipulations have direct effects on water quality, aquatic ecology, recreation and shoreline erosion.

Operation of the reservoir elevation and water retention are controlled by rule curves. Rule curves are graphs that provide targets for hydroelectric project operators. They are made by forecasting snow-melt runoff and other factors, and are determined by several agencies. Rule curves are used to control flooding, provide adequate water for power generation and irrigation and to maintain minimum flows in the river below the dam.

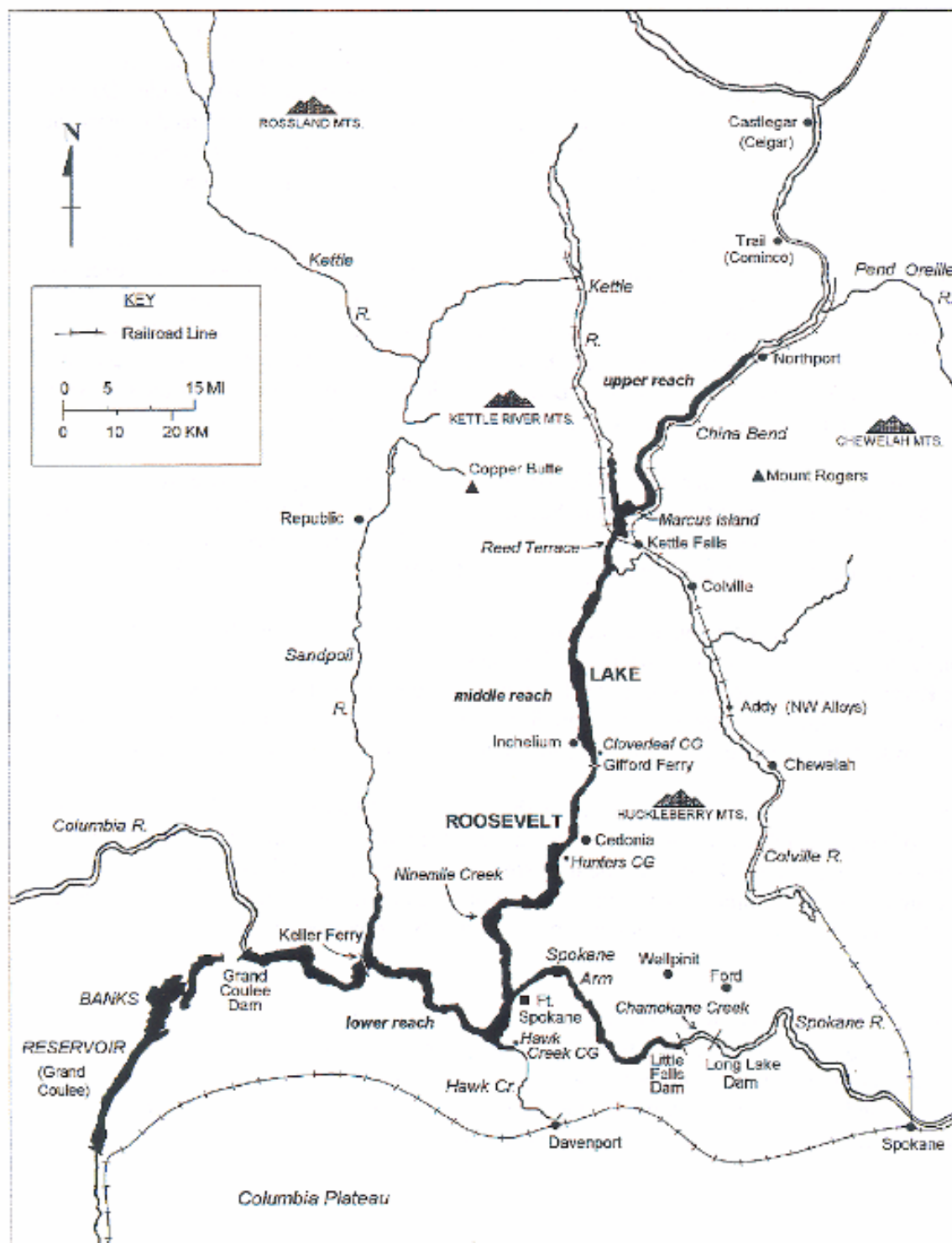


FIGURE 7. Physical Features Near Lake Roosevelt National Recreation Area.

Retention times were longer prior to 1974, when a third generator was added at Grand Coulee Dam. In 1942 when the dam was completed, outflow peaked at 92,000 cfs, while after installation of additional generating capacity, it increased to 291,000 cfs, which drastically reduced retention time. Retention times have increased slightly since 1991 due to an increased awareness of their importance to reservoir ecology. Modern retention times are typically 30-80 days, depending on runoff, demand for electricity and downstream issues (Bucy and Funk, 1996). Modern average retention time is 40 days (Bortelson et al., 1994). Water moves most rapidly through the reservoir system between March and June, and stays in the reservoir longest between September and January (Derewetzky et al., 1993).

The great storage capacity of the reservoir and large seasonal fluctuations in runoff in the watershed cause large drawdowns. Full pool elevation of Lake Roosevelt is elevation 1289 ft, while drawdowns typically average 30 ft but may reach as much as 80 ft. There is one major drawdown period, which peaks between April and May (Figure 8). The drawdown is necessary to provide storage to lessen spring flooding on the river downstream of Coulee Dam. Releases of water during power generation add daily-to-weekly complexity to the drawdown curve. Drawdown timing and elevation affect retention time of water in the reservoir.

Anadromous fish management on the lower Columbia now makes drawdown less consistent, as decisions on river discharge are made on a weekly basis. This situation is expected to get more complicated as additional attempts are made to restore Columbia River salmon runs downstream. For example, the Northwest Power Planning Council 1992 fish and wildlife program called for reduced reservoir levels to increase stream flow below Grand Coulee Dam.

HYDROGEOLOGY

Groundwater resources of Lake Roosevelt National Recreation Area are complex in distribution and the types of threats they face. Groundwater sources include the basalt flows of the Columbia Plateau region in Lincoln County, as well as the thick accumulations of glacial deposits along the reservoir shorelines and at the mouths of tributaries. Limestone bedrock near Northport may also be a potential groundwater source (Anderson, 1969).

Relatively shallow, perched groundwater occurs at varying elevations in the sand and silt glacial deposits. At Reed Terrace, Jones and others (1961) reported perched groundwater at an elevation of approximately elevation 1450 ft; 160 ft above the full pool level of the reservoir. Numerous other locations of perched groundwater exist throughout the unit. These are identified as springs and seeps along bluffs, and are often associated with large landslides (Jones et al., 1961).

Recharge areas for these small aquifers vary greatly in size and location due to topography and geology. Stevens County Planning Department *has* hired a consultant to map all aquifer recharge areas for the county. This information is expected in late 1996.

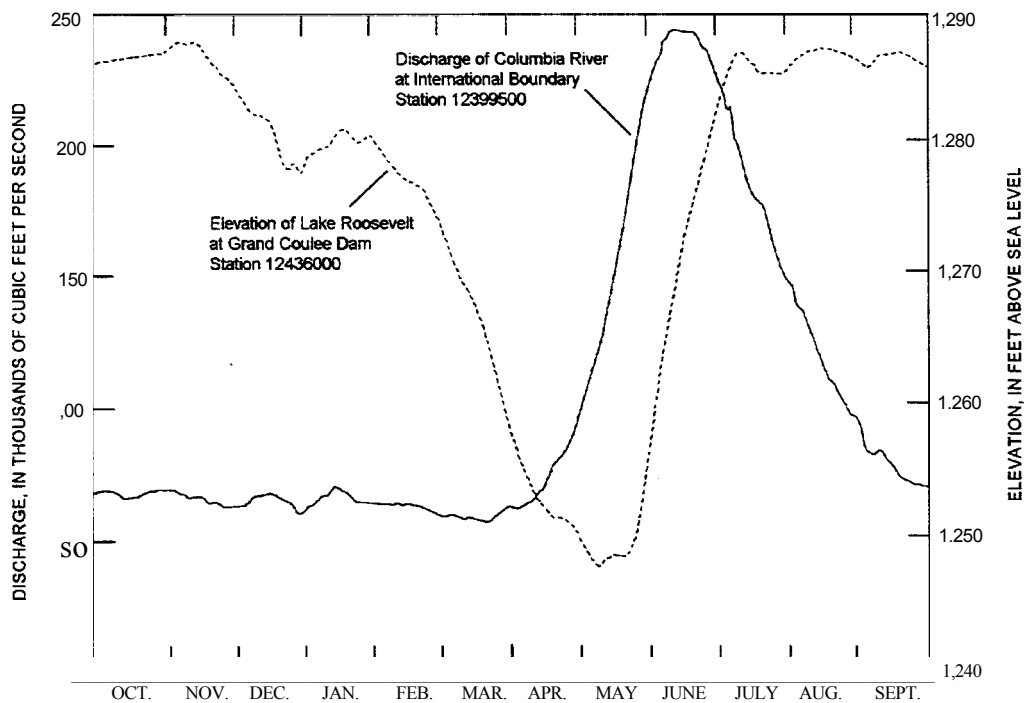


FIGURE 8. Columbia River Mean Daily Discharge and Lake Roosevelt Mean Daily Elevation Curve for 1983-92 (Source: Bortelson et al., 1994).

Present use of the groundwater resources in the eastern region of the State of Washington is considered below potentially available recharge (Cornett, 1994). Cornett (1994) notes that these aquifers are susceptible to contamination through strong surface water connections. Development at various locations within and near the borders of Lake Roosevelt National Recreation Area also present potential threats to shallow aquifers. For example, development in the Colville valley is a potential future threat to groundwater quality and quantity (Cornett, 1994).

Anderson (1969) found that some wells located near the shoreline were connected hydrologically to Lake Roosevelt, while others were not. Most facilities at Lake Roosevelt National Recreation Area rely on wells as a water source. Among reported problems, Evans Creek campground well had excessive concentrations of iron and manganese.

Development near the Spokane Arm could threaten groundwater resources in this area. Fort Spokane relied on a natural spring to provide water for its military activities in the mid-19th century, although only anecdotal information is available on this use. Monitoring began in July 1996 with readings taken daily during the summer and twice a week in the winter (no data available at present). The NPS continues to use the spring as a source of water, in combination with two wells. These and other private wells in the area typically reach between 80 and 300 ft. In the early 1990s, a request was made for a groundwater withdrawal of 1800 gallons/minute for

the 30 acre, 100 site private Wild Turkey RV park development 3 miles from Fort Spokane. The spring is located only 1000 ft from the proposed development. As the amount requested was above the state exemption, the RV park had to go through the Water Rights process. Presently there is a statewide moratorium on new water rights for the Snake and Columbia rivers. This permit will not be processed until the moratorium is lifted (1999 at the earliest). The NPS protested approval of the application to protect the source water for the spring.

Groundwater near Kettle Falls comes from two sources: a shallow, seasonal perched aquifer and a deeper, regional aquifer (U.S. EPA, 1995). The deep aquifer is located in 170-200 ft thick glacial sand and gravel deposits in the Colville Valley. Elevation of static water in wells is 1310 ft, with a hydraulic gradient sloping to the south-southwest toward Lake Roosevelt (CH2M HILL, 1993).

Groundwater at Stevens County landfill is located 300 ft beneath the surface and has a south-southwest hydraulic gradient. The landfill is lined with a leachate collection system, and several monitoring wells are located adjacent to the landfill.

LAND USE IN THE WATERSHED

Detailed statistics on land use of the Columbia watershed in Canada were not included in this report. However, population density is relatively low, and land use is generally dominated by forestry, with mining and agriculture of lesser importance.

Land use in the U.S. portion of the upper Columbia watershed varies widely due to the extreme variation in the climate and geology. Approximately 50% of the watershed in the U.S. is federally or tribally owned. Forestry dominates land use in Ferry and Stevens counties in the Okanogan Highlands. Forests account for 90% of land cover on the Colville Reservation and 78% on the Spokane Reservation. In Lincoln County on the Columbia Plateau, 90% of the land use is classified as cropland or rangeland. Commercial, industrial and residential use accounts for 6% of land use in Lincoln County and 4% in Stevens County, but less than 0.5 % in Ferry County. All counties report increases in commercial, industrial and residential land use over the past 10 years.

The State of Washington Department of Natural Resources Northeast Region oversees forest management practices on state and private land. Recent changes in the forest practice regulations have led foresters to adopt a watershed planning approach. Information on soils, slope instability, hydrology, vegetation and other features is currently being collected for watersheds draining into Lake Roosevelt.

There are four major mining districts in the watershed, including the Sullivan District in British Columbia, the Republic District in Ferry County, the Metaline District on the Pend Oreille River, and the Coeur d'Alene District in the Spokane watershed. Intensity of mining in the watershed as a whole is lower today than in the past, except for a few scattered sites such as a magnesium

mine 15 miles south of Colville. Lead and zinc are the primary metals mined and processed, while copper, gold, silver, tungsten, tin and molybdenum are also important. The minerals dolomite, silica and clay are also mined in small quantities throughout the watershed. U.S. Gypsum Inc. operates a lime plant on the shore of Lake Roosevelt near Evans Creek campground, although there are no liquid wastes associated with the operation.

Mining and mineral processing of lead and zinc peaked in the first half of the 20th century in most of the watershed, including the Coeur d'Alene mining district and the area near Northport. Three lead and zinc flotation processing mills at Northport that processed 380 tons of ore/day are now all closed (Orlob and Saxton, 1950). Gold ore processing was typically accomplished by the cyanidation process. Large quantities of uranium were mined in the 1950's from the Blue Creek watershed (Midnite Mine). In the late 1960's and early 1970's uranium was mined from the Spokane watershed (Sherwood Mne) on the Spokane Reservation, and was processed near Ford (Figure 7; Stevens County and U.S. EPA, 1993). There is presently no activity at these mines.

Industrial uses in the watershed focus on mineral refinement and forest products. Large paper and forest product mills are found at several locations. CELGAR is a bleached kraft paper pulp mill that has been in operation since 1961. It is located 35 miles north of the international boundary on the Columbia River near Castlegar (Figure 2). Expansion and modernization of this factory was completed in 1993. Boise Cascade Inc. operates a plywood mill at Kettle Falls, and another pulp mill operates on the Colville River, south of Colville. Several more pulp mills are located in the Pend Oreille watershed and other parts of Canada.

COMINCO operates the largest lead and zinc smelter in the world. It is located on the Columbia River 15 miles north of the international boundary in Trail, B.C. (Figure 2.) This plant has operated since the turn of the century and includes a fertilizer manufacturing plant. Lead and zinc smelters near Northport have been inactive for several decades, but the sites may contain toxic mill waste. Additional information on this operation is provided later in this report.

Farms on the Columbia Plateau in Lincoln County produce the most grain in the watershed. In particular, the Hawk Creek watershed receives intensive agricultural use, including application of pesticides. In several locations, grazing has negatively impacted stream banks. Grazing along Omak Creek, Little Nespelem Creek, Sanpoil River, Hall Creek, Wilmont Creek and Falls Creek has been identified as a concern (Colville Confederated Tribes, 1992).

Glacial terraces located along the lakeshore are used for a variety of agricultural purposes. These include orchards, dairies and other types of farming industries. In the Colville valley, more than 40 dairies are in operation (Stevens County and U.S. EPA, 1993). A large amount of Lake Roosevelt's water is used for the Columbia Basin Irrigation Project. Over 60 different crops are grown, including seed crops, corn, alfalfa, mint and soft fruit.

Agricultural practices are being improved in some instances in the Lake Roosevelt watershed. For example, the Spokane Tribe has initiated a dryland rehabilitation program over the last few

years on the reservation. Under the terms of this program, 1995 was a year of dormancy for all agricultural lands on the reservation. In addition, the Ferry County Conservation District is restoring overgrazed riparian areas on the Sanpoil River. As mitigation under the Northwest Power Planning Council Fish and Wildlife Program, the Colville Confederated Tribes is purchasing ranch land and restoring it to better support wildlife.

Agricultural use within Lake Roosevelt National Recreation Area is primarily grazing. There are currently 10 permits for grazing scattered throughout the unit, totaling approximately 1121 acres (NPS files). Another 50 miles of Lake Roosevelt National Recreation Area's boundary is bordered by livestock operations, and in the past three years there have been 15 case incident reports of trespass grazing. The NPS is currently phasing out these special use permits in compliance with NPS-53 and the recreation area's Special Park Use Management Plan (1990) (Taylor-Goodrich, pers. comm., 1996).

The population of two of the three counties surrounding Lake Roosevelt has grown slowly but steadily through this century. In 1940, shortly before the NPS took control of managing Lake Roosevelt NRA, the population of Stevens, Ferry and Lincoln counties was 35,537. In the 1990 census, the population of the same area grew to 46,737. Much of this increase occurred between 1970 and 1990. For example, the population of Stevens County was 17,405 in 1970, but had grown to 28,979 by the 1980 census, an increase of 65% in 10 years. Rapid population growth continued through the 1980's to 1990, albeit at a slower pace (6% growth in Stevens County). In contrast, Lincoln Counties population peaked at 17,539 in 1910. By the 1990 census, the population continued to drop to 8,864. This change is presumably due to the loss of small family farms to agribusinesses.

Most of the population growth in this region has occurred in cities. For example, Spokane, the largest city in the watershed, was 122,001 in 1940, but had grown to 177,196 by 1990. Population growth in other cities in the three county region around Lake Roosevelt National Recreation Area is given in Table 5.

TABLE 5. Population Growth in Cities Surrounding Lake Roosevelt National Recreation Area (Source: U.S. Census Bureau, 1996).

CITY	1970 POPULATION	1980 POPULATION	1990 POPULATION
Colville	3742	4510	4360
Kettle Falls	893	1087	1272
Chewelah	1365	1888	1945
Davenport	1363	1559	1502
Republic (area)	1463	2344	N/A*
Colville (Res.)	1009	1548	N/A*

*Data not available

The three counties surrounding Lake Roosevelt National Recreation Area are in various stages of compliance with the Washington State Growth Management Act. This Act, among other things, requires the counties to identify and protect "critical areas", including wetlands, geologically hazardous sites, etc. Lincoln County is classified as a "non-planning" county but has identified critical areas, bringing it into compliance. Ferry County is currently in compliance with the Growth Management Act, but agricultural lands are under a compliance order. Stevens County has not completed mapping of critical areas, but is considered in compliance because it started the planning process late. The Colville Watershed Planning project is the only one of its kind outside of Puget Sound in Washington State. This effort is being led by Stevens County and the Stevens County Conservation District.

Development and population growth are particularly rapid along the shoreline of Lake Roosevelt. A Concessions Management Plan was signed by the five entities signatory to the Lake Roosevelt Cooperative Management Agreement (1990). This plan is in effect until 2001 and provides maximum allowable limitations to 200 houseboat rentals and 250 power boat rentals, but no limitations to motorboat size. It also defines 10 development zones allowed by each concessionaire, including:

- 1) Lake View Marina
- 2) Seven Bays Marina
- 3) Spring Canyon Concession
- 4) Kettle Falls Marina
- 5) Two Rivers
- 6) McCoy's Marina - no future development
- 7) Daisy Marina - no future development
- 8) Crescent Bay at GCD - future development site
- 9) Moonbeam Bay - future development site
- 10) Inchelium - future development site

Refer to Figure 9 and Table 6 for locations and characteristics of some of these sites. The Spring Canyon, Keller Ferry, Seven Bays and Kettle Falls concessions are operated under NPS permits (Table 7). Subdivision development is also being planned at Hanson Harbor, while an 18-hole golf course and subdivision are planned for the Deer Meadows area near Seven Bays. The Spokane Tribe is constructing the Two Rivers Resort on the north shore of the mouth of the Spokane River. Near Northport, a private group is considering development of a 60 unit RV Park. Finally, the NPS is considering a proposal to develop a private marina at the mouth of the Colville River.

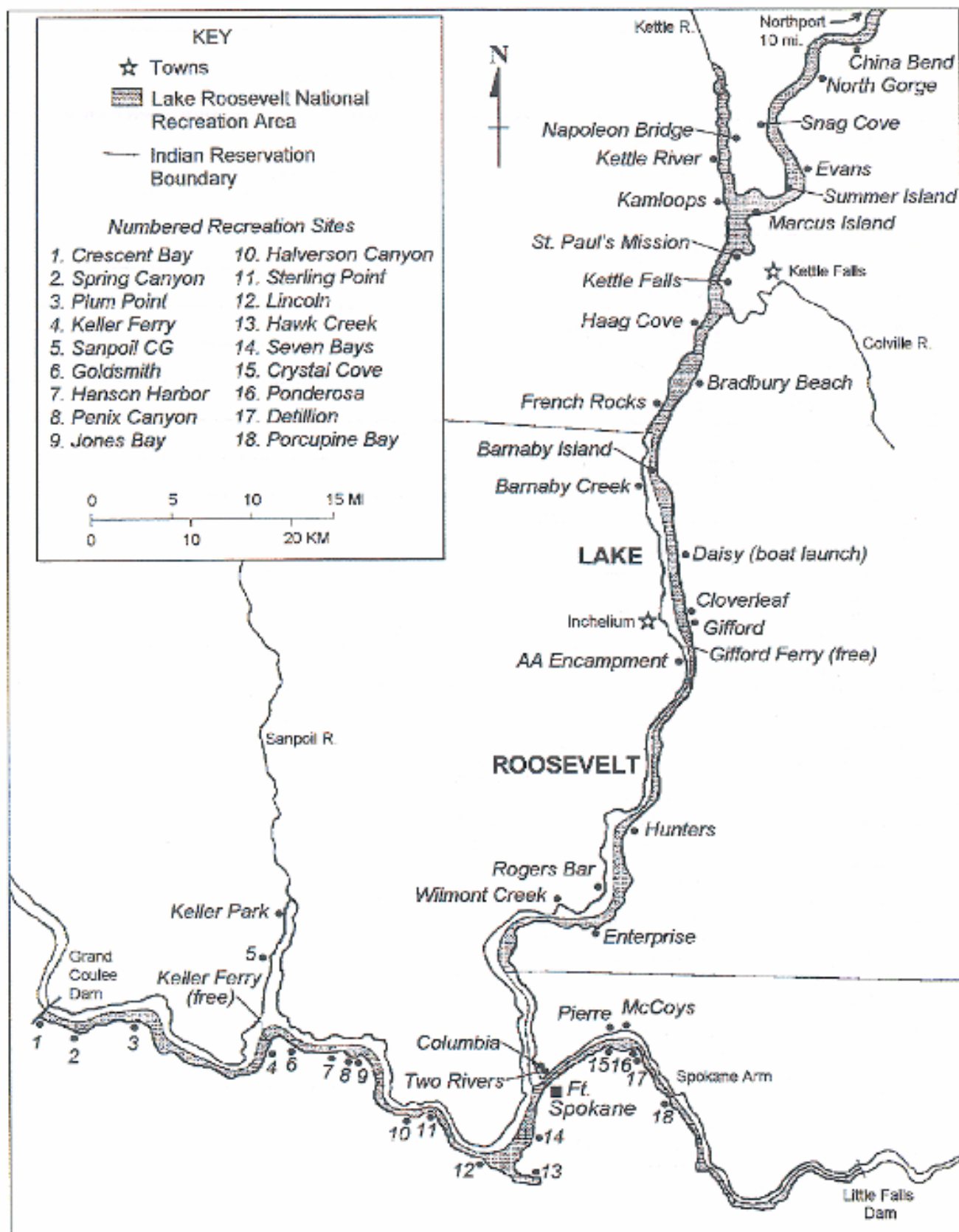


Figure 9. Recreational Facilities Adjacent to Lake Roosevelt. (See Table 6 for additional information about each site.)

TABLE 6. Lake Roosevelt Recreation Sites and Facilities (Source: NPS Files).

#'s from map	SITE	FACILITIES
1	Crescent Bay	boat ramp
2	Spring Canyon	ranger station, campground, boat launch, day use
3	Plum Point	boat-in campsites
4	Keller Ferry	campground, boat launch, marina, day use
5	Sanpoil	campground
6	Goldsmith	boat-in campsites
7	Hanson Harbor	boat launch
8	Pena Canyon	boat-in campsites
9	Jones Bay	campground, boat launch
10	Halverson Canyon	boat-in campsites
11	Sterling Point	boat-in campsites
12	Lincoln	boat launch
13	Hawk Creek	campground, boat launch
14	Seven Bays	campground, boat launch, marina
15	Crystal Cove	boat-in campsites
16	Ponderosa	boat-in campsites
17	Detillion	boat-in campsites
18	Porcupine Bay	campground, boat launch, day use
	Fort Spokane	ranger station, campground, boat launch, day use, visitor center, National Historic District
	McCoys	boat fuel
	Pierre	campground
	Two Rivers	campground, marina
	Columbia	campground
	Enterprise	boat-in campsites
	Wlmont Creek	campground
	Rogers Bar	campground
	Hunters	campground, boat launch
	AA Encampment	campground

TABLE 6. Continued

	Gifford	campground, boat launch
	Cloverleaf	campground
	Daisy	boat launch
	Barnaby Creek	campground
	Barnaby Island	boat-in campsites
	French Rocks	boat launch
	Bradbury Beach	campground, boat launch
	Haag Cove	campground
	Kettle Falls	ranger station, campground, boat launch, marina, day use
	St. Paul's Mission	historic site
	Kamloops	campground
	Kettle River	campground
	Napoleon Bridge	boat launch
	Marcus Island	campground, boat launch
	Summer Island	boat-in campsites
	Evans	campground, boat launch
	Snag Cove	campground, boat launch
	North Gorge	campground, boat launch
	China Bend	boat launch

TABLE 7. Special Use Permits (Source: NPS Files).

BY TYPE			
Agriculture	10	Mooring Buoys, Community	6
Boat Docks	14	Net Pens	6
Boat Docks, Community	13	Right of Way	3
Grazing	10	Vacation Cabin Sites	26
Industrial	1	Water Pump Pipeline	50
Miscellaneous	6	Water Pump Pipeline, Well	4
Mooring Buoys	6		
BY DISTRICT			
North	98	South	57
TOTAL NUMBER OF PERMITS, Current and Pending			155

HUMAN USE WITHIN LAKE ROOSEVELT NATIONAL RECREATION AREA

The water resources of Lake Roosevelt National Recreation Area are used for many purposes, including recreation, industry, irrigation, agriculture, domestic water supply and operation of the Columbia River hydroelectric power supply system. Recreational use of Lake Roosevelt National Recreation Area, including swimming, fishing and boating, has increased 600% in the 30 years the NPS has managed this area. A review of NPS administrative files reveals that total visitation was approximately 250,000 in 1965, but rose to 624,000 by 1984, and surpassed 1.5 million by 1990. This visitation is highly seasonal, with peak use occurring in summer.

Recreational use occurs at 28 sites managed by the NPS as well as other private and tribal sites. These sites include campgrounds, boat launches, picnic areas and marinas (Figure 9; Table 6). Twenty-four of these developments are campgrounds, including one run by the Colville Confederated Tribes. In 1991, there were 64,000 boat launchings at NPS facilities. Other facilities within the NRA included: 26 lease cabins, 257 docks and ramps (47 private), 13 picnic areas, 10 swimming beaches, 16 launch ramps, 10 dump stations, 72 campground toilets, 38 miles of roads, 9 miles of trail, 151 buildings, and 29 housing units. At many locations, private use of public lands is occurring illegally. Unauthorized roads, yards, docks and other modifications to public shorelines are a growing problem.

There are 32 aquatic species harvested by users of Lake Roosevelt National Recreation Area, most of which are fish. This harvest is regulated by Washington State Department of Fish and Wildlife regulations. Walleye, kokanee, rainbow trout, yellow perch and smallmouth bass are the primary game fish (McDowell and Griffith, 1993). Other recreational fish species include dolly varden trout, largemouth bass, lake whitefish, burbot (ling cod) and white sturgeon. Walleye accounts for 90% of the sportfish caught annually on the reservoir (Beckman et al., 1985). In the absence of native salmon runs, the Colville Confederated Tribes and the Spokane Tribe rely on walleye for subsistence.

Approximately 40% of the rainbow trout harvested are reared to size in pens, and typically are caught within four months of release, indicating high fishing pressure (Bucy and Funk, 1996). There are currently 36 net pens for rainbow trout at 6 locations on Lake Roosevelt, including Keller Ferry Marina, Seven Bays Resort, Hunters Marina, Hall Creek Marina, Kettle Falls Marina and Lincoln Mill (Figure 9). Each of these pens is capable of holding 15,000-20,000 fish, which should be enough to reach an annual target total reservoir production of 500,000 fish. The pens receive five- inch long fish from hatcheries and rear them to 8-12 inches before release. Funding for these programs is from the Bonneville Power Administration through the Northwest Power Planning Council Fish and Wildlife Program. In addition, in 1996, the Washington Department of Fish and Wildlife reared over 50,000 kokanee in net pens at the Sherman Creek Hatchery.

Concerns over the quantity of Columbia River water prompted the Washington Department of Ecology to place several five-year moratoriums on water appropriations from the surface waters of the Columbia River. The first moratorium began in 1992, while the current one is scheduled

to run until July 1, 1999. Prior to this moratorium, the NPS had permitted use of Lake Roosevelt National Recreation Area for domestic water withdrawals for developments along the reservoir shoreline. These included 50 water pump lines from the lake to developed sites (Table 7). This use was one of the primary purposes for the creation of Lake Roosevelt and is subject to state water rights approval.

WATER RIGHTS

Washington State Law

Around the time of statehood (1889) both appropriation and riparian systems of water rights were operative in Washington State. In 1917, a permit/appropriation system, as the exclusive method for obtaining water rights, was adopted for surface water. In 1945, a permit/appropriation system was adopted for ground water (Parker, 1991). The state follows the doctrine of prior appropriation, for both surface and ground water.

When an application for a water right is filed, the State Department of Ecology must find that water is available, and the proposed water use is beneficial. Beneficial uses would not impair existing water rights and would not be detrimental to the public interest. In addition, the Department may attach conditions to the permit to avoid or mitigate negative effects on other right holders or the public interest (Slattery, 1992)

The legislation of 1917 and 1945 recognized existing rights, including appropriative and riparian. However, the Supreme Court held that riparian rights not used by 1932, were forfeited, although riparian rights for non-consumptive uses, such as aesthetics and recreation, were not necessarily lost by non-use (Parker, 1991).

The 1967 legislature mandated that water right holders file claims by 1974. The deadline was later extended to September 1, 1985 (Parker, 1991). The statement of claim established the quantity and priority of the right. Through this mechanism, existing vested appropriative rights (those obtained according to law or local custom prior to adoption of the permit system) and riparian rights could be inventoried.

For groundwater, certain uses--including stockwater, domestic uses including noncommercial gardens less than one-half acre, and industrial and domestic uses of under 5,000 gallons per day--are exempt from the permitting requirements (Parker, 1991).

The Chelan Agreement, a framework document produced by the State, Indian tribes, water user groups and the environmental community, established procedures for cooperatively planning the management of Washington's water resources (Parker, 1991). As part of this cooperative planning process, instream flow needs are considered. Washington Department of Ecology can also establish water rights by "rule", on a case by case basis, through conditions on new water permits, and through the State's trust program where existing water rights are transferred to

instream uses.

Federal Reserved Water Rights

When the federal government reserves land for a particular purpose, it also reserves, by implication, enough water unappropriated at the time of the reservation as is necessary to accomplish the purposes for which Congress or the President authorized the land to be reserved, without regard to the limitations of state law. The rights vest as of the date of the reservation, whether or not the water is actually put to use, and are superior to the rights of those who commence the use of water after the reservation date.

Once adjudicated, the water rights of the United States, reserved and appropriated, fit into State priority system along with those of all other appropriators. The United States is given an opportunity to assert its claim to water rights when brought into a general adjudication. Unless legally absent from the proceedings, it is generally understood that failure to assert a claim to water rights in such a proceeding may result in forfeiture of those rights.

Sale or Lease of Water by the National Park Service

The 1970 NPS Act for Administration (PL 91-383 Section 3(e)), as amended in 1976 authorized the Secretary of the Interior to contract for the sale or lease of services and resources (including water) within an area of the National Park System under certain limited conditions.

Special Directive 78-2 (1978), Standards for Implementation of New Authorities under Public Law 91-383 reiterates items in Section 3(e) and further defines the NPS implementation requirements prior to entering into water sale or lease contracts;

- 1) Services provided by the applicant must be a direct benefit to the park or to the NPS for the direct or indirect benefit of park visitors;
- 2) Applicant has no reasonable alternative source;
- 3) Effects of water usage to the parks' environment, administration, management and protection, and visitors must be acceptable;
- 4) The use is in compliance with laws and regulations governing ownership and use of Federal water and water rights;
- 5) Full cost to the government for water use must be recovered;
- 6) Special use permit must be submitted to Congressional committees for review and concurrence;

- 7) Permitted use is temporary (one year or less) and is revocable at the discretion of the Secretary at any time without compensation or transfer of property rights. The NPS reserves the right to review and approval of planned development by the applicant that would create increased water demands.

By NPS policy, such sale or lease of water cannot result in the permanent transfer of a water right to the permittee. All rights in and to such water must remain with the U.S. (Special Park Use, NPS-53).

SURFACE WATER QUALITY

Physical

Seasonal cycles of change to physical and chemical parameters of the reservoir are related to the large inflow of water during spring runoff. These include a drop in temperature, alkalinity and conductivity (Stober et al., 1981). Reservoir operation, complex geology and a wide range of land use in the watershed produce high variability in these and other parameters of water quality between the reservoir as a whole and the Spokane Arm (Stober et al., 1981). Industries along the Columbia River, and to a lesser degree the Colville and Spokane rivers, have introduced chemical pollutants to the reservoir, which are discussed below.

Turbulent mixing by inflow causes nearly uniform lake temperature profiles to persist from October to mid-April in the entire reservoir. During the rest of the year, portions of the reservoir develop vertical temperature gradients. By mid-May, an 8 °F temperature gradient was observed in the lower reservoir below Ninemile Creek, including the Spokane Arm. Thermal stratification created oxygen depletion in the lower level (hypolimnion) and nutrient depletion in the euphotic zone (Stober et al., 1981). The upper reservoir retained a uniform temperature structure all year because of inflow mixing (Bortelson et al., 1994). Average reservoir temperature peaked from August to September (Derewetzky et al., 1993). Significant winter ice cover occasionally developed over parts of Lake Roosevelt, particularly the Spokane Ann.

Due to the large inflow of Columbia River water and short retention time of water in the reservoir, upper Lake Roosevelt did not become less than 100% oxygenated throughout 1980 (Stober et al., 1981). These researchers also measured a range in oxygen saturation from 46-160% at various depths along the entire reservoir, with surface saturation ranging from 88-131%. Annual peaks in oxygen saturation between April and July coincided with phytoplankton growth (Stober et al., 1981) and spring runoff from the watershed.

Light penetration into Lake Roosevelt is greatest at the dam and generally decreases upstream due to suspended sediment from the Columbia River (Derewetzky et al., 1993). Water transparency is greatest in winter and lowest in summer when phytoplankton populations reduce light penetration. In 1953, the U.S. Public Health Service (U.S. Department of Health, Education and Welfare) measured maximum light penetration at 15 ft. In a 1981 longitudinal

survey of the entire reservoir, maximum light penetration measured was 25 ft (Stober et al., 1981).

Chemical

The waters of Lake Roosevelt are classified as AA (extraordinary) by the Washington Department of Ecology (Washington Administrative Code 173, Section 201A). Class AA waters are the highest classification in the Washington State system. The general characteristic of AA waters is"Water quality of this class shall markedly and uniformly exceed the requirements of all or substantially all uses." This classification is viewed as a goal that the Washington Department of Ecology is working toward meeting on the reservoir, rather than a nondegradation standard (Ray, pers. comm., 1996). Water quality classifications are intended to be reviewed and reissued every three years.

Mean reservoir conductivity in 1980 measured 116 uMhos/cm in December and dropped to 100 uMhos/cm by June. Lake Roosevelt water is generally classified as soft to moderately hard. The average pH of the reservoir ranged from 6.9-8.6 in 1980 (Stober et al., 1981).

Water quality became a concern in the early 1980s when the U.S. Fish and Wildlife Service detected elevated levels of cadmium and mercury in fish from the reservoir (Lowe et al., 1985). They found that cadmium concentrations in suckers were the highest among 112 sites surveyed nationwide. Also in the 1980's, the Canadian Columbia River Integrated Environmental Monitoring Program (CRIEMP) identified dioxin and furan as pollutants in the river reach just above the border (CRIEMP, 1994). After 16 years of research, metals mercury, copper, lead and cadmium, and the dioxin and fivan compounds have become of particular concern. Water quality has also been degraded by many other types of land use in the watershed.

In broad perspective, Lake Roosevelt is a pollution trap. The severity of the problem is indicated by the fact that 18 of 41 sites surveyed between Grand Coulee Dam and Northport had trace element concentrations exceeding Canadian severe effect levels by 100% or more. Lead, zinc, copper, arsenic and copper have higher concentrations in the Columbia River and upper Lake Roosevelt. Mercury and cadmium are found in higher concentrations in the mid- to lower reaches of the reservoir (Johnson et al., 1989; 1990). Presumably these metals are associated with finer particles carried down to the dam from the head of the reservoir. CRIEMP (1994) found lead concentrations 50% greater at Kettle Falls than Northport.

Most land uses in the watershed rely on water, and most cause some level of degradation of its quality. There are many point and non-point sources of pollution in the Lake Roosevelt watershed. Bucy and Funk (1996) list potential non-point pollution sources as follows:

- 1) Reservoir shoreline erosion. A potential source of arsenic is introduced as soil erodes into the reservoir (Bortelson et al., 1994).

- 2) Agriculture. Areas where cattle are not fenced out of streams can cause local degradation of water quality. Stevens County monitors runoff from an inactive fertilizer plant in Chewelah.
- 3) Forestry. Cumulative effects from increased siltation, turbidity and soil erosion are a concern because this is the largest land use in the watershed.
- 4) Motorboats. Numbers are limited and there is no evidence of a problem at this time.
- 5) Mining. Spokane watershed is a potential source of arsenic, zinc and cadmium from leaching of mining and smelting wastes in Kellogg, Idaho. Another potential source is Big Sheep Creek, a naturally rich mineral deposit. Many other small mines and old tailings piles in various stages of activity are not monitored. The State of Washington Department of Natural Resources Minerals and Mining Division requires permits only for those mines larger than 3/4 acre.
- 6) Campsite sewage disposal. Eleven of the 24 camp sites have running water, and all but one or two remote sites have sealed-vault toilets.
- 7) Transportation. Movement of hazardous materials by Burlington Northern Railroad and on highways along the reservoir and in the Colville and Kettle valleys as well as by ferries at Keller Ferry and Gifford Ferry is a potential concern.
- 8) Air pollution. Manufacturing plants in British Columbia and the burgeoning populations along the Pacific Coast present potential threats to water quality by causing air pollution. The Lake Roosevelt Water Quality Council notes there is no data on this subject. There is no visibility monitoring at Lake Roosevelt NRA.
- 9) Shoreline development. Construction of resorts, casinos, RV parks, marinas and homes along the shores of Lake Roosevelt present threats to water quality because of wastewater, soil erosion, paint, petroleum products and contamination of surface water by oil from roads and fertilizers and pesticides from lawns.
- 10) Atmospheric deposition. Smelter, automobile, urban and other sources of atmospheric pollutants are a source of pollution to the watershed and reservoir. Emissions from the CELGAR plant in B.C. are believed to impact a very localized area (Bucy and Funk, 1996). These sources and the threats they pose to water quality are not well understood.

Point sources of pollution include a number of industrial, commercial and municipal sites in the watershed (Figure 10). In 1994, the Washington Department of Ecology issued permits for discharge of pollutants from 13 sites, three of which discharge into surface waters (Table 8). Information on these sites is presented below, beginning with wood products industries, continuing through metal processing industries, and concluding with municipal sources.

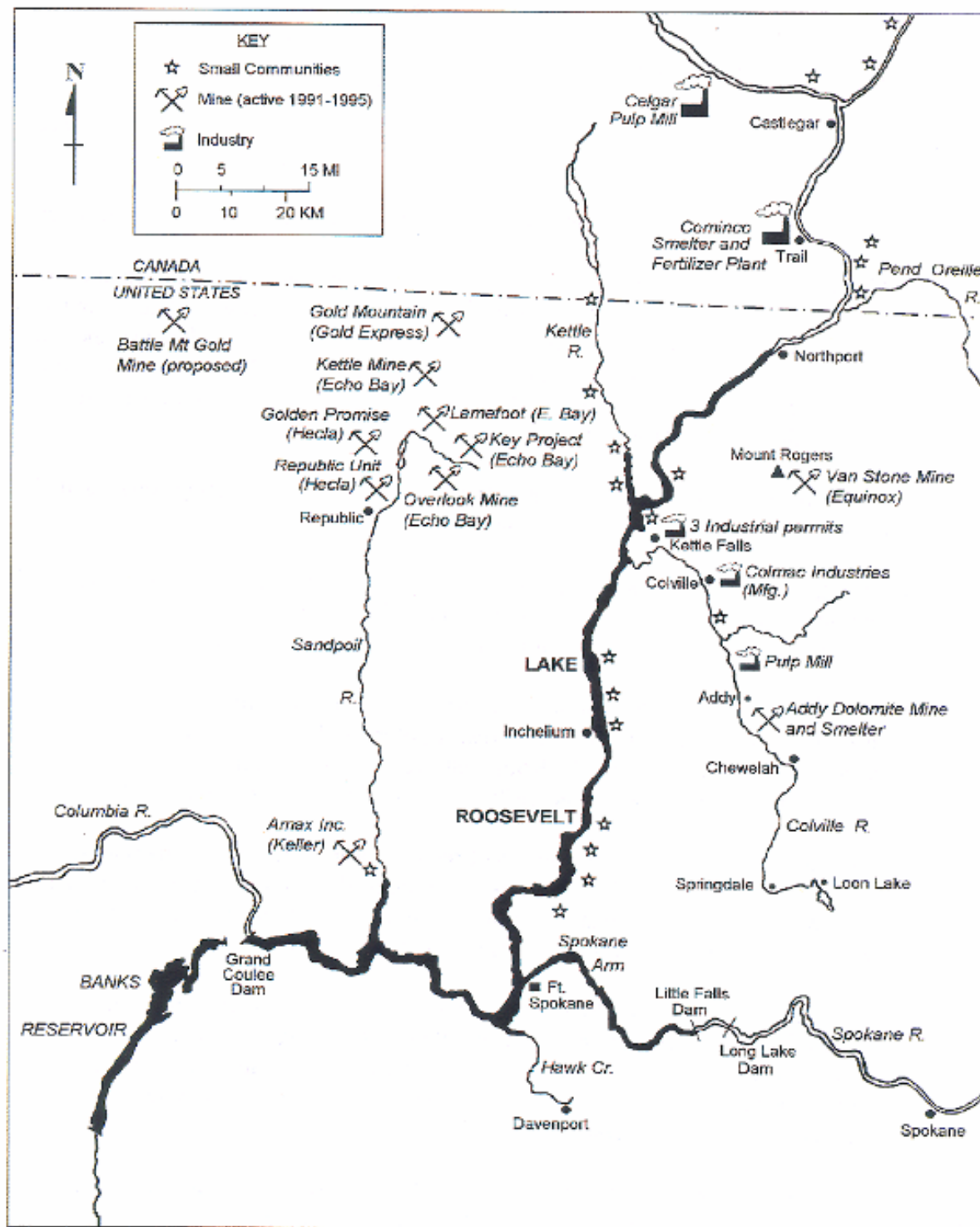


FIGURE 10. Potential Point Sources of Pollution in Lower Portion of Lake Roosevelt Watershed (Source: Derkey et al., 1992-1996, Gulick, 1995 and U.S. Department of Energy, 1991).

TABLE 8. State of Washington Department of Ecology Pollution Discharge Permits (Source: Cornett, 1994).

Basin Permittee	Basin Year#	Existing Permit		Target for Issuance	Extension After Issuance	Ecology Manager Initials
		Class	Expires			
Upper Columbia Basin	98					
Hecla Mining (Republic) (temp)	(94)	S/IL	11/1/86	1/31/94		P J H
Washington Water power (KF/GS)		mi	7/22/93			P J H
Boise Cascade/KF (Plywood)		S/IL	1/24/95			K R M
Boise Cascade/KF (Sawmill)		S/IL	1/24/95			K R M
Colville WTP		mm	4/30/95			K R M
Chewelah WTP		mm	12/17/95			P J H
Equinox Resources (Van Stone)		S/IL	5/31/96			P J H
Colmac Industries Inc.		S/IU	3/26/95			K R M
Loon Lake S.D. WTP		S/ML	12/30/96			L M 0
Republic WTP		S/ML	6/21/97			K R M
Davenport WTP		S/ML	10/12/97			L M 0
Kettle Falls WTP		S/ML	7/1/97			L M 0
**Springdale WTP		** New Plant, Completion FY 95				
Echo Bay (Republic)	(95)	S/IL	12/8/94	12/31/94	3 Yr.	P J H

Note:

- * = Target Basin(s)
- KF = Kettle Falls
- MM = Major Municipal
- MI = Major Industrial
- mm = Minor Municipal
- mi = Minor Industrial

- # = Year that watershed-wide permits granted
- WTP = Wastewater Treatment Plant
- S/ML = State Municipal to Land
- S/IL = State Industrial to Land
- S/IU = State Industrial to POTW

Wood Products Industries

CELGAR paper mill employs approximately 400 people at its Castlegar, British Columbia plant. Organochlorines were used for many years as a whitening agent in their paper manufacturing process. Discharge of 26 million gallons/day of untreated industrial effluent from the factory introduced 6,600 tons/year of organochlorine compounds, including furans and chlorinated dioxin, into the Columbia River for nearly 30 years. In 1991, CELGAR changed from elemental chlorine to chlorine dioxide processing, thereby reducing discharge of dioxins to the river. Continued modernization of its manufacturing process allowed CELGAR to stop dumping dioxin into the river completely by 1993.

Several features of the Boise Cascade Mill near Kettle Falls present potential threats to the surface water of Lake Roosevelt. In 1990, the NPS and Citizens for a Clean Columbia challenged the Washington Department of Ecology's waste discharge permit for the plant. Arguments for both sides were heard by the State of Washington Pollution Control Hearings Board. As a result of this hearing, the Washington Department of Ecology and Boise Cascade agreed to amend the permit to provide for a groundwater monitoring network and hydrologic studies of the area (Pollution Control Hearings Board, 1991). The new permit limits wastewater discharges to 112,000 gallons/day.

Runoff still occurs from log decks at the Boise Cascade Mill, which is collected in a lagoon located approximately 125 ft from the Lake Roosevelt National Recreation Area boundary and 375 ft from Lake Roosevelt (Figure 11). Discharge from the lagoon is a concern if and when preservatives are used on the logs. Potential contaminants from the 25-year-old lagoons include lead, arsenic and phenols (Lake Roosevelt NRA, 1996). These sites are discussed in the groundwater quality section of this report.

Washington Water Power Generating Station in Kettle Falls discharges treated industrial wastewater from the use of wood pulp by-products to generate electricity (Figure 11). Five Washington Department of Ecology priority pollutants were identified in the effluent, including one volatile organic compound and three metals (Pb, Zn, Hg). Levels of mercury were particularly elevated, although no toxicity was observed in three bioassays of this effluent (Washington Department of Ecology, 1990).

Other wood product mills include the Arden Pulp and Wood Products Mill north of Addy, Washington, on the Colville River, and CANCEL Mill above Castlegar on the mainstem Columbia River.

Metal Processing Industry

COMINCO in Trail, British Columbia, is the world's largest integrated lead and zinc smelter. It has been owned by various interests since operation began around 1890. British Columbia Ministry of Environment is the permitting authority for the considerable pollutants it has

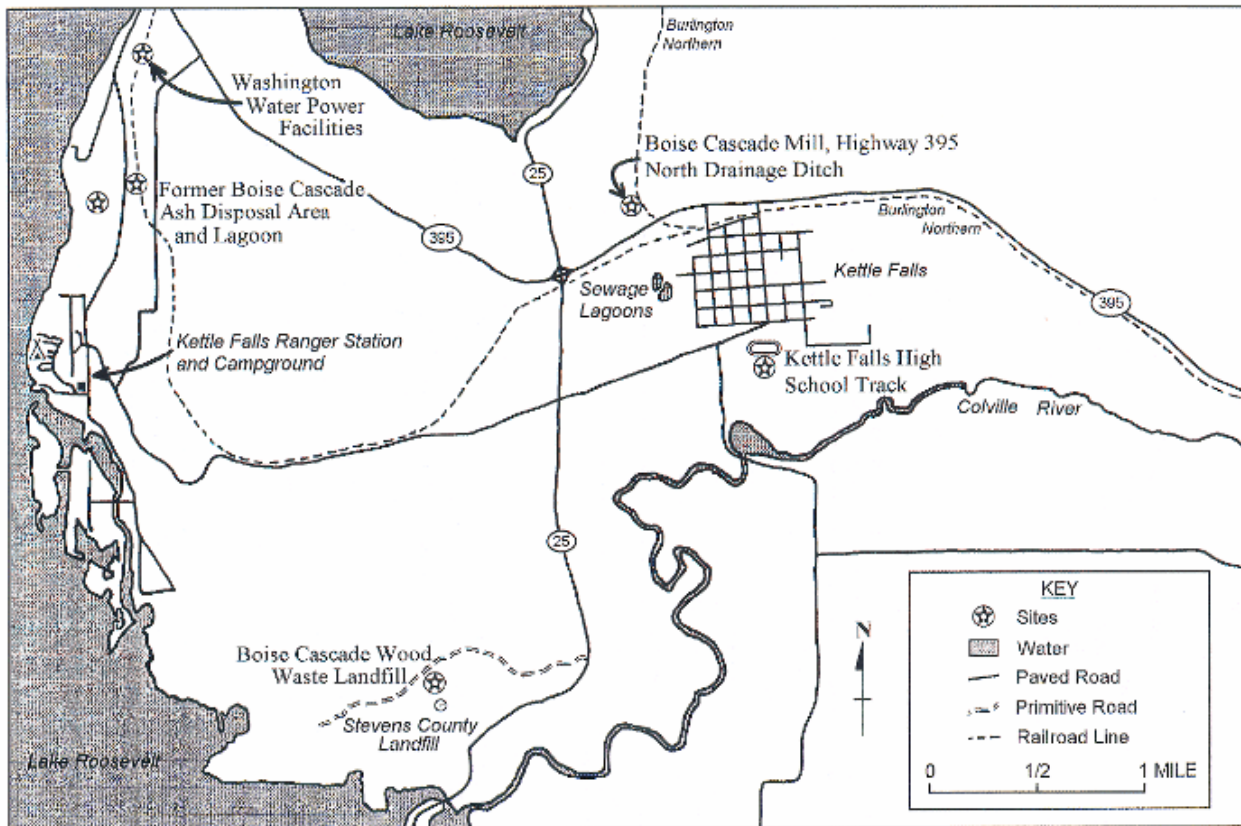


FIGURE 11. Six Sites of Potential Threats to Lake Roosevelt National Recreation Area Groundwater Resources Near Kettle Falls (Source: U.S. Environmental Protection Agency, 1995).

released into the river. Their most recent permit (# PE-02753) was extended indefinitely in 1996 (Johnson, pers. comm., 1996).

COMINCO is the largest producer of heavy metal pollution in the watershed. This plant has discharged 396 tons/day of slag into the Columbia River for nearly 65 years (Table 9). The slag is a black, sandy waste of lead and zinc smelting, with concentrations of 2.5% zinc, 0.5% copper and <0.1% lead. At a discharge rate of 396 tons/day, and a lead concentration of 0.001, this factory released approximately 700 lbs/day of lead into the Columbia River for over half a century.

TABLE 9. Cominco, 65 Years of Discharge Before 1977 (Source: Serdar et al., 1994).

DISCHARGE IN 1977 (Kg/day)	POLLUTANT	AVERAGE KG. / DAY	TOTAL KG. IN 65 YEARS	TOTAL TONS
10	Lead (Pb)	235	5,575,000	6330
8	Zinc (Zn)	232	5,504,000	6054
N/A*	Copper (Cu)	152	361,000	396
6-8	Cadmium (Cd)	13.1	311,000	342
2	Arsenic (As)	9.2	218,000	240
2	Mercury (Hg)	1.7	40,000	45

*Data not available

In addition to the slag, four sewers drained from the factory directly into the river, carrying 43 million gallons/day of a slurry containing lead, zinc, mercury, arsenic and cadmium (British Columbia Ministry of Environment, 1979; Smith, 1987). The factory is also permitted, and occasionally discharges up to 220 tons/day of concentrated sulphuric and phosphoric acid into the Columbia River (NPS, Water Resources Division file on Lake Roosevelt, 1996).

In 1989, the company predicted reduced pollution discharges with installation of a new smelter. Design flaws, however, limited the smelter to less than full capacity. With further modernization of the smelter, discharge of the slag was scheduled to be reduced to 1% of its previous total by the end of 1995. By late 1996, slag discharge was cut to 5 tons/day, and is now expected to cease in mid-1997 (Johnson, pers. comm., 1996).

Modernization plans include slag disposal in a landfill, although there may be a market for the slag as a road construction material. Future improvements also include a surface drainage control plan, a spill prevention plan and a reconfiguration of the smelter.

COMINCO's fertilizer factory discharged 2.5 tons/day of phosphorous into the Columbia River.

Recent changes at the plant have reduced this amount significantly, so that mercury and phosphorus are no longer released to the river from this operation (Jolly and Leckrone, 1993).

Mining and metal processing in the Pend Oreille and Kootenay tributary watersheds are not believed to be significant sources of metals to the Columbia River. Numerous dams on these rivers limit transport of metals downstream (British Columbia Ministry of Environment, 1979).

There are several metal industries sites and activities in the Spokane River watershed. In Silver Valley, Idaho is the Bunker Hill area, which is the second largest superfund site in the U.S. This area is a source of zinc to lower Lake Roosevelt (Yake, 1979; Johnson et al., 1994). Five dams on the lower Spokane River limit transport of some pollutants into Lake Roosevelt from the upper watershed.

Uranium and other minerals have been extracted from several mines on the Spokane Reservation, including the Sherwood Mine and Midnite Mines. The U.S. Geological Survey is monitoring for seepage of mine wastes into the surface waters of Blue Creek near Midnite mine. An Environmental Impact Statement on reclamation of this mine is currently being developed by the Bureau of Land Management, and there is a water treatment facility associated with the mine.

A study by the Washington Department of Ecology found there was no data available that indicated high concentrations of metals in the Colville, Sanpoil or Kettle rivers (Cornett, 1994). However, there are potential sources of pollutants in each of these watersheds. For example, the Republic mining district is located in the headwaters of the Sanpoil River. Also, near Keller, AMAX Inc. (a mining operation) has received an EPA pollution permit for discharge into Manilla Creek, a tributary of the Sanpoil River. Finally, a mine and smelter near Addy are located on the Colville River.

Municipal Sources

Municipal sewage is also a potential threat to the water quality of Lake Roosevelt. Trail and Castlegar, British Columbia have secondary treatment plants, but the Trail facility has released raw sewage into the Columbia River during storm water events which overload their system. There were five instances of raw sewage discharge into the Columbia River in the summer of 1995 alone. A late June storm forced release of 1 million gallons of raw sewage from the Trail facility. High coliform bacteria counts were measured in the mainstem Columbia below Castlegar at Birchbank, 17 miles downstream. Installation of a sewage treatment plant in the mid-1970's curtailed coliform in the river (Wilson, 1996).

The City of Spokane is the largest in the watershed and is located above three dams on the Spokane River. In the early 1970's, Bishop and Lee (1972) noted nutrient loading was causing the accelerated eutrophication of Long Lake and the lower Spokane River. As a result of a 1979 court order, Washington Department of Ecology determined maximum allowable allocation of discharges for the entire watershed.

Spokane now has a tertiary wastewater treatment plant that became operational in August 1977. This plant is designed to remove more than 85% of biological oxygen demand and phosphates, and greater than 90% of suspended solids. Stober and others (1981) and Wilson (1996) found total phosphorous in Spokane Ann comparable to the rest of Lake Roosevelt. However, Stober and others (1981) discovered increased nitrate levels up Spokane Arm (particularly in winter), and this watershed is believed to be a significant source of nutrients in lower Lake Roosevelt (Bucy and Funk, 1996).

Colville, Kettle Falls, Chewelah and Republic have had wastewater treatment permits from the Washington Department of Ecology (Table 8). Permits due to expire in 1995 have been extended while the Washington Department of Ecology implements a watershed approach to the permit renewal process. It is expected that most of the licensees listed in Table 8 will be reissued 5-year permits in 1998 (Ray, pers. comm., 1996).

Kettle Falls sewage treatment plant has secondary sewage treatment. Colville and Chewelah are updating primary treatment facilities that discharge directly into the Colville River. Both of these plants will have secondary treatment with nitrate removal and UV reduction of bacteria. Wastewater from the Loon Lake treatment plant is used solely for irrigation and is not believed to pose a threat to the water resources of Lake Roosevelt (Washington Department of Ecology, 1990). U.S. Census data for northeastern Washington indicates that 63% of homes were on public sewers, while 36% had septic tanks.

In 1983, the Washington Department of Ecology detected PCB's in bottom-feeding fish in the Spokane River near, and downstream of, the city of Spokane. A subsequent study in April of 1994 detected PCB's in sediments and in whole fish and fillet samples from the Spokane River upstream of Spokane down to the Spokane Arm of Lake Roosevelt. Levels of PCB's were highest upstream of Spokane and decreased downstream, with the lowest levels found in Lake Roosevelt. The source(s) is not known, although PCB levels upstream at Post Falls, Idaho were lower than just above the city of Spokane. Interpretation of results from an EPA study conducted in 1995 has not been completed. Results were released to the Lake Roosevelt Water Quality Council in June of 1996, and a final report is due at any time.

Water Quality Trends

Initial studies of the water quality of Lake Roosevelt in the 1940's suggested that the reservoir was essentially free of pollutants (Derewetzky et al., 1993). Following the first identification of pollutants 30 years later, trends in the level of pollutants in Lake Roosevelt have improved.

Changes to the CELGAR and COM NCO plants, in particular, have resulted in reduced pollutant concentrations in the water and suspended particles of Lake Roosevelt. In a comparison of data collected between 1980 and 1994, the Washington Department of Ecology noted that dioxin and furan concentrations dropped significantly after 1990. Furan concentration dropped over 50% between 1990 and 1993, while no dioxin was detected after 1990 (Serdar et al., 1994). Several studies have concluded that concentrations of metals have dropped significantly due to changes

at COMINCO, including the decreased discharge of sewers (Serdar et al., 1994; Johnson et al., 1989). The Washington Department of Ecology found that except for mercury, metal concentrations dropped between 10-44% for various metals between 1992 and 1993 samplings. They note, however, that despite these decreases, metal concentrations remain high.

The Washington Department of Ecology reported concentrations of 1.0-2.7 ug mercury/g dry weight in bottom sediments. These were two times the level observed upstream of the COMINCO and CELGAR mills in Arrow Lake and in tributaries (Johnson et al., 1989). The existence of metals in the massive volume of slag and finer deposits at the bed of the reservoir presents a long-term pollution problem.

A recent summary of the water quality of Lake Roosevelt identified important trends in several other physical and chemical parameters between 1981 and 1994 (Bucy and Funk, 1996). Lake temperature has not changed significantly, while dissolved oxygen decreased. This decrease is believed to be related to gas supersaturation as water spilled over upstream dams in the earlier sampling period. Current trophic status of the lake was generally classified as mesotrophic to slightly eutrophic in 1980 (Stober et al., 1981). The Washington Department of Ecology reported that in the reservoir as a whole, nitrate and total phosphate decreased between 1980-1994 (Serdar et al., 1994). Secchi disk depths increased steadily over the same period, reflecting increased light penetration. Increases at some sites sampled were 50% or more.

The Columbia River Integrated Environmental Monitoring Program (CRIEMP) also provided a retrospective view on nearly 15 years of analysis of water and sediment quality (CRIEMP, 1994). They found concentrations of mercury, cadmium, lead, dioxin and furans in Columbia River sediments increased between 1982 and 1990. The highest concentrations of these substances were found below the COMINCO mill near Trail, British Columbia. Further, downstream in Lake Roosevelt, most toxins were found in fine-grained sediments. By 1994, CRIEMP found dioxin and furans to be within "acceptable" levels.

GROUNDWATER QUALITY

Groundwater quality is highly variable within the perched aquifers of the glacial bluffs along the reservoir. Anderson (1969) examined groundwater samples from 35 development sites. The samples were generally described as hard, with a high iron content.

Wells at Hunters, Hawk Creek, Spring Canyon, Keller Ferry, Fort Spokane and Detillion had coliform contamination problems in the 1970s. The NPS addressed these threats by adding chlorinators at most sites and iodine treatment systems at others. A complete listing of wells at Lake Roosevelt National Recreation Area and their characteristics is given in Table 10.

There are several sites near Kettle Falls where groundwater quality is threatened. These include the Boise Cascade wood-waste landfill, the former Boise Cascade ash disposal area, the Boise Cascade log yard lagoon, the Washington Water Power facilities, the Stevens County landfill and

TABLE 10. Locations and Characteristics of Wells and Associated Water Systems at Lake Roosevelt National Recreation Area (Source: M.K. Deal, Water Systems Operator, Lake Roosevelt NRA, pers. comm., September, 1996).

LOCATION	DEPTH (ft)	YIELD (GPM)	USE TYPE	OTHER
Bradbury Beach	78	20	seasonal	iodine treatment, hand pump
Camp Neighborly	120	34	seasonal	chlorine treatment, 300 gal. tank
Detillion	17	5	seasonal	iodine treatment, hand pump
Evans Camp	200	14	permanent	chlorine treatment, 1,000 gal. tank
Porcupine Bay	190	20	permanent	chlorine treatment, 22,000 gal. tank
Snag Cove	20	20	seasonal	iodine treatment, hand pump
Spring Canyon	183	200	permanent	chlorine treatment, 20,000 gal. tank
Kettle R. Camp	39	75	seasonal	iodine treatment, hand pump
Keller Ferry Camp	131	100	seasonal	chlorine treatment
Keller Ferry Marina	160	90	permanent	chlorine treatment, 1,000 gal. tank
Gifford Camp	152	50	seasonal	chlorine treatment, 600 gal. tank
Haag Cove	59	15	seasonal	iodine treatment, hand pump
Hunters Camp	90	15	seasonal	chlorine treatment
Hawk Creek Camp	30	5	seasonal	iodine treatment, hand pump
Kamloops Island	93	15	seasonal	iodine treatment, hand pump
North Gorge	40	20	seasonal	chlorine treatment, solar pump
Marcus Island	200	20	seasonal	iodine treatment, hand pump
Cloverleaf	28	12	seasonal	iodine treatment, hand pump
Fort Spokane #1	200	25	permanent	chlorine treatment, 1,000 gal. tank
Fort Spokane #2	80	20	seasonal	summer irrigation source
Ft. Spokane Spring	N/A	N/A	winter	historic reservoir 186,000 gallons

the former tailing piles near Kettle Falls High School (Figure 11; U.S. EPA, 1995). Each of these sites is discussed below.

Tailings piles at Kettle Falls High School track were tested and found to be high in manganese (Figure 11). EPA also found arsenic, cadmium, copper, mercury and chloroform in soil samples

taken from the tailing piles.

Citizens for a Clean Columbia raised concern over the Boise Cascade ash disposal area, which is an unlined landfill west of Kettle Falls (Figure 11). The mean pH of numerous ash samples was measured at 11. Subsequent testing revealed three volatile organic compounds and elevated levels of copper, manganese and di-n-butylphthalate at the site (U.S. EPA, 1995). Concentrations were all below EPA levels for safe public use. Ash from the mill has been taken to the Stevens County landfill for disposal since 1979. EPA has contracted with URS Consultants to monitor six wells in the Kettle Falls area, while Boise Cascade and Stevens County monitor other wells.

The Boise Cascade wood-waste landfill covers 5 acres and is located southwest of Kettle Falls (Figure 11). Seepage from the log yard at the Boise Cascade Mill in Kettle Falls enters Lake Roosevelt near the full pool elevation of the reservoir. At this location, a layer of lacustrine silt and clay perches lagoon seepage. Sediments beneath the lagoon were tested by the NPS Water Resources Division in 1990. Phenols, toluene, xylene, arsenic, zinc, manganese, lead and copper were at elevated levels (Water Resources Division file, 1996). Boise Cascade has retained Cascade Earth Sciences Ltd. to conduct quarterly sampling of two seeps below the lagoon. Testing parameters include chemical oxygen demand, chloride, phenolics, total dissolved solids, tanin and lignin, iron and manganese.

Other landfills are located in the U.S. part of the watershed. These include a Ferry County landfill near the Sanpoil River, which monitoring has shown to have elevated levels of some organic volatile compounds. Three landfills located in Lincoln County are all closed. State regulations require 20 years of groundwater monitoring of closed landfills. These efforts are being undertaken by Ferry and Lincoln counties.

AQUATIC ECOLOGY

Closure of Grand Coulee Dam in 1939 essentially destroyed the native riverine ecology of the mainstem Columbia River and the mouths of several of its tributaries. Grand Coulee Dam flooded several hundred miles of anadromous fish spawning and rearing habitat, creating a reservoir ecosystem in its wake. Larger tributaries that enter the upper Columbia, including the Kootenay and Pend Oreille in Canada and the Spokane in Washington have also been dammed and flooded (Figure 5).

Native anadromous fish that were the heart of the riverine ecosystem were excluded from the reservoir ecosystem by the physical barrier of the dam. Average losses were estimated at 128,000 spring chinook salmon, 213,000 sockeye salmon and 148,000 steelhead (Beiningen, 1976). A five year program to help fish pass Grand Coulee Dam was abandoned, and there are currently no fish passage structures or programs. King salmon and silver salmon no longer are a significant part of the Lake Roosevelt ecosystem. Many other species of plants and animals were also effectively removed from the mainstem Columbia once the reservoir was created.

Smaller tributaries such as the Sherman Creek and the Kettle and Sanpoil rivers have built deltas and wetlands at their junctions with Lake Roosevelt. They currently provide the best available riparian spawning habitat in the unit (Fulton and Laird, 1967). Fulton and Laird (1967) measured 174 miles of spawning habitat on these three rivers, and estimated that 326 miles were blocked by natural and artificial structures. Flood plains at the mouths of the Kettle and Colville rivers are managed by the NPS. The Sanpoil watershed is managed by the Colville Confederated Tribes.

Reservoir Ecology

Early ecological development in the reservoir was determined to be comparable with other large reservoirs by Gangmark and Fulton (1949), although the U.S. Department of Health, Education and Welfare (1953) noted the reservoir's low biological productivity. Development of a new reservoir ecosystem has been dependent on physical constraints created by operation of Columbia River dams and by pollution from adjacent point and non-point sources. Traditional operation of the Columbia River Power Supply System for flood control, power generation and irrigation is also now complicated by attempts to enhance salmon migration downstream on the river. The primary physical constraints created by these operational factors are the annual drawdown and the retention time of water in the reservoir.

Annual drawdown of the reservoir results in rapid shoreline erosion, which, combined with the steep unstable shorelines, limits littoral development (Stober et al., 1981). Therefore, wetlands are scarce along the reservoir shoreline. Drawdown reduces spawning habitat, kills eggs by exposing them to subaerial conditions, and has complicated effects on predator-prey relationships.

Retention time of water in the reservoir has been shown in numerous studies to effect the entire ecology of the lake. Longer retention times of water in the reservoir allow populations of plankton and other organisms at the base of the food chain to develop, which has benefit for the entire lake ecosystem, including predators at the top of the food chain such as trout and walleye (Bucy and Funk, 1996). Fifty day retention time seems to be a key level for the development of the reservoir food chain. Spring retention times less than 50 days shows effects throughout the succeeding year.

On a smaller scale, habitat in the reservoir is manipulated through the removal and recently, the collection and anchoring of woody debris by the Bureau of Reclamation and other agencies. These structures are known as artificial reef complexes and are used to enhance fish production. They are collections of woody debris from shorelines bound together and submerged 10 ft below full pool elevation of 1290 ft. Six of these structures have been constructed to date, with fourteen more in the planning stage.

Twenty-eight genera of phytoplankton form the basis of the reservoir food chain, with most primary production occurring in the upper 26 ft of the water column (Figure 12)(Stober et al., 1981). Twelve species of green algae (*chlorella* and *ankistrodesmus*) and five species of

diatoms (*asterionella*, *fragilaria* and *mesolaria*) are the dominant phytoplankton in the reservoir (Stober et al., 1981). Average silica concentration between 1982 and 1992 of 4.7 mg/l is more than adequate for diatoms, which require a minimum of 0.5 mg/l to compete with other algae (Derewetzky et al., 1993). Most primary production by these organisms occurs in the upper 26 ft of the reservoir, with a peak in June and a low in February (Stober et al., 1981).

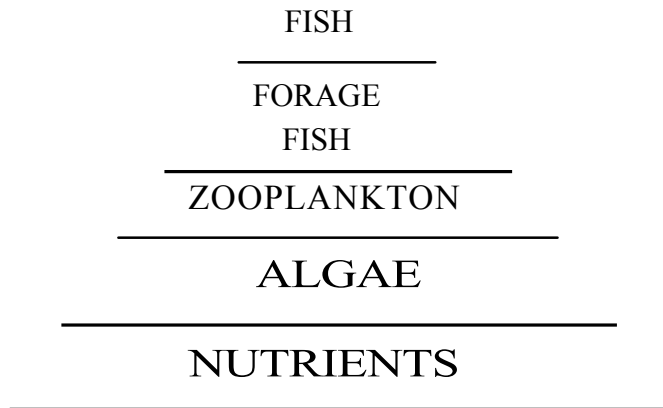


FIGURE 12. Ecological Pyramid in Lake Roosevelt (Source: Stober et al., 1981).

Red algae were reported at the mouth of the Sanpoil River and in Crescent Bay. The Bureau of Reclamation identified the species as the dinoflagellate *perionium*. The green algae *cladophora*, a species with a branched form that attaches to the reservoir bed is also common. It was identified as a problem in Lake Roosevelt by the NPS (Lake Roosevelt NRA files, 1996).

Nutrients phosphate and nitrate limit phytoplankton growth in Lake Roosevelt. Stober and others (1981) found that nitrate and orthophosphate concentrations dropped in spring and summer with growth of phytoplankton standing crops. Standing crop of phytoplankton is limited by nitrate availability in the lower reach of the lake and by phosphate in Spokane Arm (Stober et al., 1981). Standing crops of phytoplankton are greatest in Spokane Arm and decrease both up and down lake. Turbulence and lower light penetration in the upper reach limit algae growth (Derewetzky et al., 1993).

There are 42 species of zooplankton in Lake Roosevelt. Nineteen species of rotifera, and cladocera and copepoda are the dominant genera. Rotifers dominate the reservoir in winter, while copepods flourish in summer (Stober et al., 1981). Peak zooplankton densities occur in August and September, which is earlier than in many mountain lakes (Kiser, 1964).

Benthic organisms have received relatively little attention, but Bortelson and others (1994) found species diversity and abundance low in the upper reach of the reservoir. Chironomids and

Oiligochetes (worms) were the dominant species found. Mayfly and stonefly nymphs were found in the upper reservoir, but not in the lower reach (Derewetzky et al., 1993).

Higher in the reservoir food chain, several species of native and non-native fish inhabit the reservoir (Table 11; Figure 12). Some, such as the native rainbow trout and kokanee salmon feed primarily on zooplankton. Others, such as the introduced walleye, feed on other fish and occupy the highest level in the food chain with the bald eagle and osprey, among others (Griffith and Scholz, 1991).

Limited numbers of some species of anadromous fish, such as sockeye salmon, adapted to the reservoir environment and dam blockage. Beckman and others (1985) suggested that development of the salmonid fishery in the reservoir is limited by spawning habitat and dam entrainment. They also proposed that kokanee salmon would be more likely to survive competition with walleye than rainbow trout.

Kokanee salmon were native to the Columbia River and survived flooding of the valley because they had adapted to the natural lakes in the watershed. Shortly after closure of the dam in 1942, a large number of kokanee (land-locked sockeye) salmon in Lake Roosevelt died. These fish were believed to be from Arrow Lakes, British Columbia. Kokanee population in Lake Roosevelt was stable and large in the mid-1960's, but installation of a third generator at the dam in 1974 had serious detrimental effects. The new generator increased power production, which increased the drawdown and reduced retention time. Larger and more lengthy drawdowns exposed eggs and reduced cover for young fish, while also limiting development of phytoplankton. There is still a small native run of kokanee that is supported by recent construction of two hatcheries, one located near Ford (operated by the Spokane Tribe) and the other at Sherman Creek (operated by the State of Washington Department of Fish and Wildlife). These hatcheries were funded by the Bonneville Power Administration through mitigation as directed by the Northwest Power Act (1980). Kokanee population has increased slowly through the 1990's as a result of the hatchery effort (Bucy and Funk, 1996).

In addition to rainbow trout, many other native species have been planted in the reservoir. In 1992, 1.75 million king (chinook) salmon were planted in the Sanpoil River, Spokane River and mainstem Columbia near the Kettle River and at Gifford Ferry. Large numbers of kokanee salmon were planted early in the life of the reservoir. Between 1942 and 1945 alone, 7.5 million fry were planted (Lake Roosevelt NRA, 1996). Most of these *efforts* were viewed as failures (Lake Roosevelt NRA, 1996).

White sturgeon and bull trout are sensitive indigenous species. Rainbow trout, northern squawfish, burbot, and mountain whitefish also continue to inhabit the reservoir. Native bull trout, burbot, and white sturgeon populations have declined significantly in the last 10 years, in part due to predation by and competition with introduced species such as walleye. Walleye are also known to compete for spawning beds with native northern squawfish. Rainbow trout are stocked by Washington State Department of Fish and Wildlife and by the Colville Confederated Tribes. Net pens produce 40% of the rainbow trout in the reservoir.

TABLE 11. List of Fish Species Inhabiting Lake Roosevelt (Source: McDowell & Griffith, 1993).

SPECIES	STATUS
Bass, Largemouth (<i>Micropterus salmoides</i>)	Introduced, game fish
Bass, Smallmouth (<i>Micropterus dolomieu</i>)	Introduced, game fish
Bullhead, Yellow (<i>Ictalurus natalis</i>)	
Burbot (<i>Lota Iota</i>)	Native, recent population decline, also: Ling cod
Carp (<i>Cyprinus carpio</i>)	Introduced, nuisance species
Chiselmouth (<i>Acrocheilus alutaceus</i>)	
Chub, Lake (<i>Couesius plumbeus</i>)	
Crappie, Black (<i>Pomoxis nigromaculatus</i>)	Introduced, game fish
Crappie, White (<i>Pomoxis annularis</i>)	Introduced, game fish
Dace, Leopard (<i>Rhinichthys faicatus</i>)	
Dace, Long nose (<i>Rhinichthys cataractae</i>)	
Dace, Speckled (<i>Rhinichthys osculus</i>)	
Peamouth (<i>Mylocheilus caurinus</i>)	
Perch, Yellow (<i>Perca flavescens</i>)	Introduced game fish
Salmon, Kokanee (<i>Oncorhynchus nerka</i>)	Native, stocked, also: Sockeye salmon
Salmon, Chinook (<i>Oncorhynchus tshawytscha</i>)	Native, stocked, also: King salmon
Sculpin, Mottled (<i>Coitus bairdi</i>)	
Sculpin, Prickly (<i>Cottus asper</i>)	
Sculpin, Shorthead (<i>Coitus confusus</i>)	
Sculpin, Slimy (<i>Coitus cognatus</i>)	
Sculpin, Torrent (<i>Coitus rhotheus</i>)	
Shiner, Redside (<i>Richardsonius baleatus</i>)	
Squawfish, Northern (<i>Ptychocheilus oregonensis</i>)	Native
Stickleback, Threespine (<i>Gasterosteus aculeatus</i>)	
Sturgeon, White (<i>Acipenser transmontanus</i>)	Native, sensitive species, recent population decline

TABLE 11. Continued

Sucker, Bridgelip (<i>Catostomus columbianus</i>)	Also: Columbia Smallscale Sucker, Columbia Finescale Sucker
Sucker, Largescale (<i>Catostomus macrocheilus</i>)	Also: Colorado River Sucker, Coarsescale Sucker
Sucker, Longnose (<i>Catostomus catostomus</i>)	
Sucker, Mountain (<i>Catostomus platyrhynchus</i>)	
Sunfish, Pumpkinseed (<i>Lepomis gibbosus</i>)	
Tench (<i>Tina tinca</i>)	Introduced, nuisance species
Trout, Brown (<i>Salmo trutta</i>)	Introduced, game fish
Trout, Bull (<i>Salvelinus confluentus</i>)	Native, sensitive species, recent population decline
Trout, Dolly Varden (<i>Salvelinus malma</i>)	
Trout, Eastern Brook (<i>Salvelinus fontinalis</i>)	Introduced, game fish
Trout, Rainbow (<i>Oncorhynchus mykiss</i>)	Native, stocked, raised in net pens for release
Walleye (<i>Stizostedion vitreum</i>)	Introduced, game fish
Whitefish, Lake (<i>Coregonus clupeaformis</i>)	
Whitefish, Mountain (<i>Prosopium williamsi</i>)	Native
Whitefish, Pygmy (<i>Prosopium coulteri</i>)	

Bald eagles seem to have adapted to the flooding of the valley, although population estimates prior to dam completion are not available. There are currently 12-15 bald eagle nests in or near Lake Roosevelt National Recreation Area. In addition, an over-winter population of approximately 250 eagles use the area. There are no known studies of the effects of fish toxicity on bald eagle reproduction at Lake Roosevelt National Recreation Area. Other avian species using Lake Roosevelt National Recreation Area include Canada geese, osprey, great blue heron and 20 species of migrating waterfowl and songbirds. Critical habitat for these and other aquatic species are the extensive wetlands at the mouths of the Colville and Kettle rivers.

Non-native Species

Many species have been introduced to Lake Roosevelt in its more than 55 years of existence. The Lake Roosevelt Property Owners Association, among others, signaled a warning about Eurasian milfoil (*myriophyllum spicatum*) infestation of the impoundment. Spokane Arm is an area of particular concern because of rapid development in this area. This species could threaten recreational swimming and boating and the reservoir's fishery. In 1989 a Colville Confederated Tribes employee corresponded to the NPS that milfoil was found near British Columbia on the

Columbia River, on the Pend Oreille River, and in the Little Pend Oreille Chain of Lakes (tributary to the Colville River). In 1994, the Stevens County Noxious Weed Board contracted with Resource Management, Inc. to do an aquatic weed survey for Stevens County. The Colville and Kettle river mouths and the north shore of the Spokane Arm were surveyed for aquatic plants. Small populations of Eurasian milfoil were found in the Colville River mouth area and in the Spokane Arm (Underwood, 1995).

A wide variety of non-native fish species now inhabit Lake Roosevelt. Many of the fish species introduced to the lake are viewed as desirable game fish, while others are regarded as nuisances. Undesirable fish species such as carp and golden tench, were introduced during the first few years that Lake Roosevelt existed. Non-native walleye pike and yellow perch are largely viewed as desirable species by many people. Walleye alone account for 90% of the gamefish caught in Lake Roosevelt. Concerns for the walleye population led to harvest limits imposed in the mid-1980's (McDowell and Griffith, 1993).

Walleye are also known to compete for spawning beds with native northern squawfish. They focus spawning in Spokane Arm where drawdown effects are not as large compared to the steep slopes of the main reservoir shoreline. Walleye population is believed to be limited by forage fish; not spawning habitat (Bucy and Funk, 1996). Yellow perch are another introduced but desirable species. Large, lengthy drawdowns negatively affect yellow perch by reducing spawning areas and by making them more vulnerable to walleye predation.

Ecological Impacts of Water Pollution

Deterioration of water quality and reservoir operation have had detrimental effects to the entire reservoir ecosystem, particularly species at the top of the food chain. Pollution affects the fishery by direct toxicity to species, and indirectly by biomagnification of pollutants in the food chain.

Bioassays of the environmental effects of slag and other pollutants were tested by Canadian and U.S. researchers. In 1992, Environment Canada reported that the slag from COMINCO was not inert, as previously believed, based on bioassays of 5 aquatic species (Nener, 1992). U.S. Geological Survey and Washington Department of Ecology studies show slag has physical (abrasion) and chemical effects on the Columbia River ecosystem, including Lake Roosevelt (Bortelson et al., 1994; Serdar, 1993). Three benthic organisms tested by Bortelson and others (1994) had high rates of mortality in sediments from the north end of the reservoir, where COMINCO slag deposits are concentrated.

The first indication of a pollution problem with the Lake Roosevelt fishery came in 1985, when the U.S. Fish and Wildlife Service reported higher than ambient levels of cadmium and lead in fish tissue (Lowe et al., 1985). In 1988, high levels of metals and dioxin/furan compounds were detected in Columbia River fish from Canada. Canadian and American health advisories followed in 1988, 1989 and 1991. The advisories focused on walleye, whitefish, rainbow trout and white sturgeon because these species concentrated pollutants in their tissue.

A consortium of Canadian government and industry monitoring water pollution on the Columbia River described relative fish toxicity as (CRIEMP, 1994):

whitefish > sturgeon > sucker > rainbow trout and kokanee > walleye and burbot.

Bottom feeders such as suckers and sturgeon have the highest contamination, particularly cadmium. While contamination in predators such as walleye, trout, kokanee and burbot are close behind. Walleye, in particular, are known to concentrate mercury in their tissue (Serdar, 1993). Native rainbow trout are at greater risk than their pen-raised cousins. The pen-raised trout have lower toxicity because they are fed commercial food during their first year prior to release.

High concentration of pollutants in the Lake Roosevelt food chain has resulted in the issuance of several health advisories for the Columbia River in Canada, the U.S. and Lake Roosevelt. In 1991, the State of Washington Department of Wildlife issued a health advisory that suggested reducing fish consumption, eating younger fish, and removing skin and fat. This advisory was still in effect pending completion of a five-year EPA study on dioxin and furans expected in late 1995. Two fish consumption advisories were in effect for the Columbia River in Canada between 1992-95. One was for mercury in walleye, the other for dioxin and furans in mountain and lake whitefish. In March 1995, the mountain whitefish advisory was canceled, but the lake whitefish advisory is still in effect and the walleye advisory is currently under review.

U.S. Department of Agriculture takes action when levels for mercury concentration are 1 mg/Kg, while the Canadian level is a more conservative 0.5 mg/Kg. Wilson (1994) found mercury concentrations in fish tissue ranged from 0.11 to 0.62 mg/Kg along the reservoir. CRIEMP observed average concentrations of mercury in walleye of 0.15 mg/Kg from samples collected near Hawk Creek, and 0.16 mg/Kg at the mouth of the Colville River. In a more recent survey, the highest mercury concentration found in walleye along the reservoir was 0.44mg/Kg (Munn et al., 1995).

Trends in contaminant concentration vary depending on species selected. For example, concentration of metals such as cadmium in bottom feeders, like largescale suckers, remain high, while water quality has generally improved over the past few years. Concentrations of pollutants in fish are generally greater at the north end of the reservoir (Serdar et al., 1994). At Grand Coulee Dam, fish tissue samples tested above the 85th percentile for lead in the U.S. A 1992 Canadian Columbia River fish health study found that 50% of mountain whitefish sampled had lesions, tumors, fin damage, infections and parasites.

STAFFING AND ONGOING PROGRAMS

The resource management division at Lake Roosevelt National Recreation Area consists of a Division Chief (Karen Taylor-Goodrich), an Archeologist (Ray DePuydt) and a Natural Resources Specialist (Scott Hebner). There is no water resource management program at Lake Roosevelt National Recreation Area. This unit has 1.5 FTE's (full time equivalent position) devoted to natural resources management. The NRA has identified the need for 3 FTE's (full time equivalent position), including one to deal with water resource management. The NPS Natural Resource Management Assessment Program (NR-MAP) provides a workload estimate that includes 3.7 FTE's in a variety of water related categories (Table 12). While this estimate is admittedly rough, it demonstrates that a work load as well as a need for specialized expertise, exists far in excess of what Lake Roosevelt NRA can currently devote to water resources management.

TABLE 12. Natural Resource Mapping Assessment Program (NR-MAP) Estimates for FTE's Necessary to Manage Water Resources at Lake Roosevelt National Recreation Area.

WATER RESOURCE CATEGORY	NR-MAP FTE
Miles of streams: 25	0.55
Natural lakes (>2.5 acres, <1,000 acres): 1	0.11
Reservoir: 1 (80,000 acres total)	1.09
Number of developed areas on shore: 45	
Acres palustrine (marsh, wetland): 20,000	0.55
Number of springs used by visitors: 1	0.11
Water Right appropriation	0.20
Water Resource Management - Total	2.60
WATER RELATED RESOURCES	
Aquatic Vegetation	0.33
Fish	0.76
Water and related resources management - Total	3.69

Forty NPS areas manage large reservoirs, but only a few of these have staff in water resource management, including Glen Canyon (1.4 FTE), Lake Mead (1.2 FTE), North Cascades (0.7 FM), Curecanti (.35 FTE) and Whiskeytown (.15 FM). Amistad, Bighorn Canyon and Voyagers are NPS units with water resources similar to Lake Roosevelt National Recreation

Area and a lack of water resource management staff (Goldsmith, pers. comm., 1996).

Lake Roosevelt National Recreation Area has a Natural Resources Management Plan approved in 1996. This plan lists two projects under the general heading of water resources. They are Prepare Water Resource Management Plan (LARO-N-004.000) and Study Effects of Toxic Sediments on Lake Roosevelt (LARO-N-005.00). Additional project statements that might be included as water resource issues are: Control Spread of Noxious Weeds (LARO-N-010.00), Research White Sturgeon Populations and Ecology (LARO-N-025.00), Participate in Bank Stabilization and Debris Control (LARO-N-042.00), Wetlands Inventory (LARO-N-008.00), Develop a Tributary Monitoring Plan (LARO-N-006.00), and Develop a Fishery Management Plan (LARO-N-027.00).

Lake Roosevelt National Recreation Area recently purchased spill booms for emergency response to releases of toxic materials at marinas, campgrounds and other facilities. They are currently deployed at 11 locations throughout the unit.

The interpretive division, with assistance from the Washington State University Water Research Center, has created the "Floating Classroom", a two-day water quality lab field trip conducted from houseboats on Lake Roosevelt. This effort educates local high school students in water quality issues and sampling techniques, and attempts to repeat some of the water quality parameters tested by Stober, Funk and others. Although limited by the students' inexperience and a lack of funding for sophisticated testing equipment, approved techniques are used whenever possible for these basic tests. Park staff maintain contact with other individuals and agencies directly involved in a wide range of monitoring activities, including the tribes, U.S. EPA U.S. Geological Survey and the Water Research Center at Washington State University.

The lack of staff dedicated to water resources management has generally limited the NPS role in the multi-agency management of water resources at Lake Roosevelt.

Information Management

As noted throughout this report, Lake Roosevelt has been the subject of a wide variety of water resources-related studies over the past two decades. A recent scan of data within the Environmental Protection Agency's STORET data system included one state survey (Washington Department of Ecology) and four federal surveys (U.S. Geological Survey, U.S. EPA, U.S. Forest Service and Bureau of Reclamation)(NPS, 1995). The STORET survey identified nine sites within the NRA boundary that have long-term records consisting of multiple observations for several important water quality parameters. The survey also indicated that STORET data exists for all NPS Inventory and Monitoring Level-I parameter groups for Lake Roosevelt NRA (NPS, 1995). These data are currently available within the National Recreation Area on a series of diskettes generated as part of this survey.

There is Geographic Information System hardware and software at Lake Roosevelt National Recreation Area, but no funds to staff a GIS position. Data layers available through the

Columbia Cascades System Support Office in Seattle include hydrography, boundaries, transportation, topography and wetlands. The Washington State Department of Natural Resources has type-2 soil survey layers for Ferry and Stevens counties and temperature and precipitation coverages for the state. The U.S. Natural Resources Conservation Service has soil coverages available for Lincoln and Grant counties. The Colville Confederated Tribe maintains the most complete GIS database for the watershed.

There is a need for larger scale wetlands mapping at existing and potential development sites. Information on groundwater resources could also be further developed. Well log data is available at county seats.

Air photos of Lake Roosevelt National Recreation Area are taken annually by the Bureau of Reclamation.

WATER RESOURCE ISSUES & CURRENT MANAGEMENT ACTIONS

Four issues were identified in a 1994 workshop sponsored by the Lake Roosevelt Water Quality Council on the Columbia River between Grand Coulee and Hugh Keenleyside dams. The issues were: dam operations, health concerns, contaminants and system wide management (Bucy and Funk, 1996). The issues facing the NPS described below, fall within the four general issue categories listed above. The issues discussed below, however, provide detail on certain critical aspects of these general issues for the National Park Service.

1. Role of NPS in Management of Water Resource Issues. The sheer size of Lake Roosevelt's watershed, lack of staff dedicated to water resource management, jurisdictional authority of a multitude of agencies, and uncertainty regarding legislative mandates and cooperative management agreements all obscure the direction of water resources management by the NPS at Lake Roosevelt National Recreation Area.

This unit has always been a National Recreation Area. The limited guidelines available include direction provided by the Recreation Advisory Council (Executive Order 11017, 1962), the Lake Roosevelt Cooperative Management Agreement (1990), and the 1992 Statement for Management document prepared by the NPS.

Foremost among these agreements is the Lake Roosevelt Cooperative Management Agreement, which binds the NPS to a multi-agency approach to water resource management. This has positive and negative aspects. On the positive side, a large cadre of technical expertise is available to the NPS, and the weight of many agencies can help secure funds to address issues and bring pressure to bear to effect change. The Concessions Management Plan (1991) is an excellent example of interagency cooperation on Lake Roosevelt management. The Colville Confederated Tribes, the Spokane Tribe and the Bureau of Indian Affairs created the plan, which is in effect until 2001. On the negative side of cooperative management, is a lack of clear responsibility among the many agencies.

Currently, most management activity regarding the water resources of Lake Roosevelt is being directed by the Lake Roosevelt Water Quality Council. The Washington Water Research Center has prepared a Lake Roosevelt Management Plan at the direction of the Lake Roosevelt Water Quality Council. They are also developing jurisdictional matrices to aid in decision making and problem solving. This effort and others like it in the watershed will help to untangle the jurisdictional authorities of all agencies managing Lake Roosevelt. When completed, this document will help identify the NPS role in management of the reservoir. It is critical that the NPS continue to maintain a high profile in the Lake Roosevelt Cooperative Management Agreement committees. Hiring of NPS staff with water resource management responsibilities would help insure continued contribution.

Since Lake Roosevelt is one part of a large reservoir system on the Columbia River in the U.S. and Canada, big picture issues such as survival of anadromous fish runs can obscure problems associated with Lake Roosevelt. Finally, jurisdictional authority remains an issue between the

NPS and Spokane Tribe. The two parties continue to disagree over who has the authority to manage the Spokane Arm of Lake Roosevelt.

2. Surface Water Quality. The NPS has no authority to regulate sources of pollution in most of the watershed, but has a mandate to insure recreational/user health and safety. The waters of Lake Roosevelt were originally classified as AA extraordinary by the State of Washington Department of Ecology. In the early 1980s, serious water pollution problems were detected by the U.S. Fish and Wildlife Service after a study of fish tissue. The pollutants included a wide range of metals, dioxin and furan. The metals and dioxins were believed to come primarily from a smelter and wood products mill in British Columbia.

Recent events offer optimism that the introduction of pollutants by major sources is abating. Most importantly, COMINCO made a significant reduction in the amount of toxic slag it dumps into the Columbia River since July 1995. Discharge went from 396 tons/day to approximately 5 tons/day, and is tentatively scheduled to cease in 1997. Further, CELGAR has ceased dumping furans and dioxins into the river. Several recently completed retrospective studies confirm decreased levels of pollutants in the water and suspended particles. Serdar and others (1994) suggested "at this point in time there appears to be little use in monitoring metals in the water column".

Despite this progress, long-term threats to water quality remain severe. They include land use, exploding recreational use, continuing discharges from factories, and the existence of millions of tons of toxic slag on the bottom of Lake Roosevelt. Coarse grained bed sediments at the north end of the reservoir contain higher concentrations of zinc, lead and copper, while finer grained sediments downstream have higher concentrations of mercury and cadmium. Paper mills in the Pend Oreille watershed are an uninvestigated potential source of dioxin/furan pollution.

Marinas, campgrounds and other large developments along the reservoir are potential future threats to water quality. Sanitary facilities at these developments, and boat fuel and cleaning solvents at marinas are of particular concern. Ten recreational sites along the reservoir still have pit toilets, while the remaining 24 have running water or sealed-vaults (Bucy and Funk, 1996). Counties regulate private sewage disposal systems along the reservoir shoreline.

The NPS has not been able to follow its General Management Plan-stated goal of developing a systematic water quality monitoring program. NPS involvement in water quality monitoring is limited to an educational program with area high-schoolers. This program is run by the interpretive division at Lake Roosevelt National Recreation Area, and is associated with the Washington State University, Water Research Center. The State of Washington Department of Ecology exercises water quality authority over all federal agencies in Washington, and therefore takes the lead in monitoring the quality of water in Lake Roosevelt. They maintain computer files of water quality complaints by river basin. The Washington Department of Ecology has signed Memorandum of Agreements with the three adjoining counties and the U.S. Forest Service to conduct water quality monitoring.

Water quality monitoring with various methods and sample designs has been conducted sporadically since the late 1940's and 1950's. Broad scale baseline water quality measurements with standardized methods were first completed in the late 1970's (Stober et al., 1981). In the early 1990's many of the baseline parameters were remeasured using the same protocols as the previous study by Stober and others (1981) (Serdar, 1993).

Ongoing monitoring activities include several permanent sites monitored monthly by the State of Washington Department of Ecology on a five-year rotation (1995 sample year). The Water Research Center at Washington State University is currently conducting a 2-year assessment based on a retrospective analysis of data following the protocols of Stober and others (1981). Study metrics are secchi disc, vertical profiles of dissolved oxygen, conductivity, pH, alkalinity, chlorophyll A, ammonia, nitrate/nitrite, total nitrogen, orthophosphate, total phosphorous, metals, silica, Ca-Mg hardness, suspended solids, and zooplankton and phytoplankton species and abundance. The Boise Cascade plant in Kettle Falls has a State of Washington Department of Ecology waste discharge permit (No.5262 1-24-90) that requires monitoring for total petroleum hydrocarbons, oil, pH, chemical oxygen demand, formaldehyde, phenols, metals and PCB's . Sampling frequency varies from one sample every three months to one a year.

Long-term monitoring of basic water quality parameters on Lake Roosevelt is being conducted by the Spokane Tribe under the Lake Roosevelt Fisheries Monitoring Program. The parameters tested on a monthly basis are alkalinity, pH, conductivity, dissolved oxygen, temperature, rapid bioassessment, and chlorophyll A. Another long-term monitoring effort on the Columbia River above Lake Roosevelt (not including Canada) is the U.S. Geological Survey's National Stream Quality Accounting Network (NASQAN), which operates a permanent station near Northport. Over 70 parameters are tested on a monthly or quarterly basis. Other NASQAN stations are located upstream near the border on the Kootenai and Pend Oreille rivers.

Many other agencies are monitoring the water quality of Lake Roosevelt and the Columbia River upstream, including the U.S. EPA Lake Roosevelt Water Quality Council, the Colville Confederated Tribes, British Columbia Ministry of Environment, U.S. Forest Service, and Lands, Parks and Environment Canada. County health districts also manage water quality complaints, but are less willing to share this information than the Washington Department of Ecology.

Due to a lack of some pollutants in the water column and variable data, Serdar and others (1994) recommend that future work with metals focus on the sediments at the bed of the reservoir. Species targeted would include benthic organisms and others such as a bottom feeder like the largescale sucker, and predators that bioaccumulate toxins such as walleye and mountain whitefish. Due to high concentrations of dioxins and furans in water and fish tissue, Serdar and others (1994) also recommend that dioxin and furan concentrations continue to be monitored in the water and in fish tissue.

Derewetzky and others (1993) recommend a two-cycle monitoring approach. During the first cycle, comprehensive sampling would follow the methods and sampling strategy of Stober and

others (1981). During the second sampling cycle, less intensive sampling of a selected subset of water quality parameters would be undertaken. Basic ecological factors such as nutrients, zooplankton and phytoplankton would be sampled. These researchers also recommend biennial conferences to share information.

Despite the deep, long-term involvement of other agencies in monitoring a variety of water quality metrics, there is very little monitoring of recreational effects on water quality, and the threats poor water quality have on recreational use of Lake Roosevelt. Health departments from the surrounding counties have conducted sporadic measurement of coliform bacteria at swim beaches. However, neither the Northeastern Tri-County Health District (Ferry, Stevens and Pend Oreille counties) nor Lincoln County have monitoring programs. The Northeastern Tri-County Health District suggested that rapid water movement through the reservoir makes routine testing of questionable value.

Several groups have identified the need for monitoring bacteria in the waters of Lake Roosevelt. For example, the Colville Confederated Tribes recently suggested monitoring six swimming areas and four marinas within Lake Roosevelt National Recreation Area, especially the Hawk Creek Area. A 1992 NPS proposal to the Natural Resource Protection Program estimated annual costs of \$38,000 for this type of effort.

In summary, there are several agencies with greater technical expertise and facilities than the NPS currently monitoring the water quality of Lake Roosevelt. Of particular importance are the Washington Department of Ecology, the U.S. Geological Survey, Spokane Tribe and the Lake Roosevelt Water Quality Council programs. Overlapping jurisdictional authority and the size of the watershed also limit NPS ability to carry out water quality monitoring independent of the other agencies. A bacteriological monitoring program at recreation sites is a notable deficiency among current water quality programs.

3. Ground Water Quality and Quantity. NPS and private recreational facilities around Lake Roosevelt exploit groundwater resources. The NPS maintains 20 wells at 19 development sites. The extent and quality of these resources, however, is poorly understood. Generally, there are numerous small perched aquifers in the thick accumulation of glacial sediments adjacent to the reservoir. These relatively shallow, perched aquifers are prone to contamination through strong surface connections.

The quality of the groundwater resources is highly variable. Anderson (1969) examined samples from 35 development sites around Lake Roosevelt National Recreation Area. He qualitatively described the groundwater as hard with a high iron content. Wells at Hunters, Hawk Creek, Spring Canyon, Keller Ferry, Fort Spokane and Detillion recreation sites had high coliform counts in the early 1970's. The addition of chlorinators and iodinator at these and other development sites appears to have stemmed this problem.

Groundwater resources are also threatened by industry near Kettle Falls. In the early 1980's, the NPS joined Citizens for a Clean Columbia in contesting the Washington Department of Ecology

permits for wastewater disposal at these sites. Five sites in this general area were studied by the EPA and the Washington Department of Ecology for potential groundwater contamination problems. Although high concentrations of pollutants were found in soils at these sites, there has not been any confirmed contamination of groundwater to date. These sites are being monitored by the Boise Cascade Company and Stevens County.

Groundwater resources are also threatened by development near Fort Spokane. The proposed Wild Turkey RV Park and other developments are believed to threaten the spring used by the Army during their occupation of Fort Spokane in the mid-19th century. The development called for an 1800 gallon/minute withdrawal from a well located approximately 1000 ft from the spring. The NPS has limited discharge data for this, as well as other springs and seeps scattered throughout the unit. In July of 1994, the NPS filed a formal "protest" with the Washington Department of Ecology against this large withdrawal citing concern for the source of the water for the historic water system. This permit is on hold until a state moratorium for new water rights on the Columbia River is lifted. When the moratorium is lifted, each individual or group who filed a "protest" will be contacted by the state regarding the well before a decision is made. In recent years, maintenance staff have voiced concern about declining water flow from the spring at Fort Spokane. On July 11, 1996, a flow meter was installed to assess the daily flow rate. The meter is checked daily in the summer and three times a week in the winter.

4. Land Use. Authorized and unauthorized use of Lake Roosevelt National Recreation Area resources and shorelines for private developments, mining and agriculture continue to be a threat. Land use regulation on a watershed scale is beyond the direct influence of the NPS. However, recent events offer encouragement that expanding local populations may not continue to impact sensitive lands adjacent to the reservoir. For example, compliance by Stevens and Ferry counties with the Washington State Growth Management Act should control future growth.

Agricultural land use practices are generally improving. Information on improving grazing practices is available via the Washington Department of Natural Resources, the Consolidated Farm Service Agency and the Natural Resources Conservation Agency. Mining activity in the U.S. portion of the upper Columbia watershed is minimal due to low market prices. Washington Department of Natural Resources manages mining activities with a permit and inspection program.

The Stevens County Conservation District headed by the Natural Resources Conservation Service has conducted watershed ranking and planning for watersheds in Stevens County. This planning effort is the first of its kind in Washington State outside Puget Sound. The goal is to develop a watershed management plan in 19 designated subdistricts. The citizens group Kettle River Advisory Board was formed in 1993 to address growing concern over water quality. The Board monitored thirteen sites for one year.

Development along the waterways of Washington state is controlled by numerous agencies. Washington Department of Fish and Wildlife administers the state hydraulic permit program.

The U.S. Army Corps of Engineers administers those portions of the Clean Water Act that concern modification of shorelines. A section 404 permit is required for significant actions, although the NPS can use a national permit for certain actions on federal land. The state and federal permits are required when any disturbance occurs below the ordinary high water mark of a water body, except on the Spokane Reservation. In addition, the counties administer the state shoreline program for the Department of Ecology. None of these programs assesses the cumulative effects of proposed actions, which is a potential concern for the NPS. The Colville Confederated Tribes are currently developing a Shoreline Management Plan for tribal lands.

On NPS-managed land, managers face several problems. For example, in the 1950's, the NPS permitted construction of 26 private cabins on its land. Another example is the proposed RV development near Fort Spokane that threatens the historic spring. Also, a proposed Marina development at Colville Flats would require displacement of 0.12 acres of wetland. Finally, grazing and other land uses permitted on NPS property need careful review to insure they are not impacting water resources of the unit. The NPS needs to develop spatial analytical ability to address these problems (i.e., develop GIS or Geographic Information System data). GIS capability would also help address many other issues such as water quality, recreation, erosion control and long-term planning for the watershed.

5. Erosion Control. Erosion causes considerable damage to shoreline resources along the 435 miles of shoreline managed by the NPS. Erosion problems persist primarily because of the annual drawdown of Lake Roosevelt. Erosion of shorelines occurs primarily as large landslides located at hundreds of sites along the reservoir. Several studies have shown that the larger the annual drawdown of Lake Roosevelt, the greater the number of landslides.

The size and complexity of these landslides makes most site-specific mitigation beyond the scope of the agencies managing the reservoir. The Bureau of Reclamation has attempted to reduce the number of landslides by controlling the size and rate of the annual drawdowns. These actions alone probably do more to mitigate this problem than any on-site engineering ever could.

Currently, the NPS is not directly involved in management of the shoreline erosion problem, and the Bureau of Reclamation is the lead agency on erosion control. Since the early 1960's, they have photographed the reservoir shorelines annually to keep track of new and existing landslides. Previous monitoring activities were conducted by the U.S. Geological Survey in 1941-1953 and 1960-73. Apparently, some landowners were offered buyouts by the federal government following this study. The Bureau of Reclamation has taken limited engineering action to mitigate erosion at Lake Roosevelt. In the early 1990's, the Colville Confederated Tribes had a program of low-cost stabilization with debris removal as part of a federal jobs program (program now defunct). The Bureau of Reclamation base budget funds this tribal project.

At issue, is what the NPS will do about the continuing loss of resources caused by bank erosion. Any active measures would need to be coordinated with the Bureau of Reclamation. There appears to be a need for a comprehensive plan to manage this problem, including an

identification of resources threatened and a prioritization of site mitigation activities in an erosion control plan. Jones and others (1961) classified all reservoir shorelines into five categories: likely to fail, unlikely to fail, existing slide areas, bedrock and indeterminate. This work is an excellent beginning to a comprehensive management approach to this problem. If this information was combined with locations of valuable resources, then the NPS would have the basic information necessary to prepare a prioritized erosion control plan.

At the Lincoln Mill landslides, it was determined that subsequent mitigation must be done in concert with upslope mitigation to be directed by the Washington Department of Ecology. Due to other priorities, no mitigation has yet occurred. In January of 1996, the NPS wrote a letter of concern to the Washington Department of Ecology over the lack of action. To date, no further activity has occurred on either side of the issue.

Also important is the impact of bank erosion on water quality and primary production (Bucy and Funk, 1996). Bortelson and others (1994) suggest bank sediments may be a source of arsenic to reservoir waters. The amount of phosphorus introduced by bank erosion, and its effect on primary production and fisheries in Lake Roosevelt are also unknown.

6. Fishery and Aquatic Ecology. Operation of the reservoir appears to have limited ecological development in the reservoir. In particular, large drawdowns and associated short retention times of water, limit the standing crop of plankton that form the basis of the food chain in the reservoir, and can affect spawning and predator-prey relationships.

Degraded water quality has had serious detrimental effects on the reservoir ecosystem. Bioaccumulation of toxins in species targeted by recreational users and the tribes has resulted in several health advisories for Columbia River and Lake Roosevelt fish. Of particular concern, are bottom feeders like sturgeon, and predators such as smallmouth bass and walleye.

Concentrations of pollutants in fish tissue also needs to be carefully monitored since Lake Roosevelt is host to growing sport and subsistence fishery. Many of the agencies that monitor water quality also sample fish tissue and other organisms such as plankton and benthos on an irregular basis. The Spokane Tribe conducts creel surveys and fish sampling on Lake Roosevelt, and the Colville Confederated Tribes conduct irregular surveys and sampling. They also monitor zooplankton, tag net pen trout and operate kokanee hatcheries. Washington Department of Fish and Wildlife monitors the white sturgeon recreational fishery. The NPS has a critical role to play in educating visitors about fish contamination.

Lake Roosevelt Water Quality Council in 1993 identified the following fishery research needs:

- 1) Determine if water retention time is adversely affecting the zooplankton standing crop, and the effects henceforth on the fishery;
- 2) Determine the effect of reservoir operation on the food base of Lake Roosevelt sportfish;

- 3) Determine distribution patterns of hatchery-raised kokanee after their introduction to Lake Roosevelt;
- 4) Establish an age-class structure for game fish (larval through adult);
- 5) Determine the nutrient budgets of the reservoir and its tributaries, and their potential to affect the fishery;
- 6) Establish the effect of annual drawdown and its relation to spring spawning game fish (walleye and perch);
- 7) Determine if recent environmental changes have caused the abundance of species to fluctuate: and
- 8) Determine the important characteristics of the sturgeon fishery in Lake Roosevelt.

Benthic organisms have not been widely studied in Lake Roosevelt. Their proximity to pollutants in reservoir bottom sediments makes them an important group to monitor.

The lack of Lake Roosevelt NRA staff with expertise in aquatic ecology limits what this unit can offer toward solving these problems. The NPS Water Resources Division, the Biological Resources Division of the U.S. Geological Survey, cooperative management partners, and other agencies are potential sources of expertise that could assist Lake Roosevelt resource managers.

An important aspect of this issue is context. The reservoir based resources of Lake Roosevelt must be viewed in the context of the entire upper Columbia River ecosystem. For example, on the lower Columbia River, recent proposals to allow larger instream flows to enhance the downstream riverine environment for salmon, threaten the stability of the reservoir ecosystem by lowering retention times and increasing drawdowns. Further, predator-prey relationships and competition for habitat with hatchery fish often place native species in direct competition with introduced species. For example, hatchery-raised kokanee and rainbow trout compete with native kokanee and trout. At issue for the NPS, is whether to manage for the benefit of native or subsistence/recreationally valuable species when a conflict arises.

A related issue is whether or not the NPS is viewed as a fish and wildlife management agency in the upper Columbia basin (see earlier discussion of this). Clearly, the NPS has an important role to play in this area, and it is important that the NPS be recognized. The NPS has a vital role to play in managing recreational use of the aquatic resources of this unit.

7. Emergency Response Planning. Transportation of hazardous material across the reservoir on ferries and adjacent to the reservoir on train tracks and highways, and storage of hazardous materials at marinas and other developments, makes this an important issue for protecting water quality. Waves as high as 65 ft caused by landslides are also a potential safety threat to recreational users. Since the NPS permits several concessions, and has infrastructure,

equipment, and detection capabilities beyond those of many other agencies, it has an important role to play in this area.

8. Baseline Inventory and Monitoring. Wetlands, springs, seeps, wildlife nesting sites, critical habitat and other resource inventories are needed so that the NPS can respond to development and other land use proposals in and near its boundaries. Resource management staff at Lake Roosevelt National Recreation Area notes the need for more detailed wetland maps, particularly at development sites along the reservoir shoreline. Wetland mapping in the National Wetlands Inventory, at 1:24,000 scale, is not detailed enough for site-specific development proposals. The unit should include wetlands mapping in funding requests for Development Concept Plans.

9. Non-native Species. Eurasian milfoil is a potential threat to the ecology of the Lake and has been observed on the Columbia River above Lake Roosevelt and within the waters of the reservoir in the Spokane Arm (Lake Roosevelt NRA, 1995). *Mysis relicta* is another non-native species found in Lake Roosevelt in the 1970's that threatens the zooplankton community and results in the decline of kokanee salmon on the Pend Oreille River upstream of Lake Roosevelt National Recreation Area. There is a need for periodic comprehensive surveys of milfoil and other nondesirable species. There may also be a need for a visitor education program at boat ramps.

10. Staffing. Lake Roosevelt National Recreation Area managers need to determine what their role should be in the management of the water resources of the unit. There are currently no staff resources committed to water resource management at Lake Roosevelt National Recreation Area. The NPS Natural Resources Mapping Analysis Program (NRMAP) identified the need for 2.6 FTE's in water resource management, and another FTE for aquatic ecology/fisheries. There are 39 other NPS units that manage reservoirs or large lakes and several with similar sized water bodies, including Voyagers, Amistad and Curecanti. Of these three, only Curecanti has staff in water resources management, with 0.35 FTE. At the very least, there is a need at Lake Roosevelt National Recreation Area for a water resource coordinator to act as a liaison to the other agencies managing Lake Roosevelt.

11. Water Rights. Visitation at Lake Roosevelt National Recreation Area and development adjacent to and beyond the NRA's boundary is increasing. NPS and non-NPS claims exist for water sources within the NRA. Protection of the aquifers that supply the 21 wells and springs the NPS uses at developed sites is a critical issue. Recharge is low in the area's semi-arid climate, and many of the wells are shallow and penetrate only perched aquifers.

The NPS needs to establish water rights at these sites to protect water supplies from rapid development along the reservoir shoreline. Foremost among these cases, is the historic spring at Fort Spokane, which supplies most of the water to the numerous NPS developments in the area. The spring is threatened by the Wild Turkey RV park and several other residential developments nearby.

The April 1990 Lake Roosevelt Cooperative Management Agreement confirms that Lake

Roosevelt NRA is subject to NPS laws, regulations, policies and guidelines. New applications for water withdrawal from the mainstem Columbia River are currently prohibited by the Washington Department of Ecology. These moratoriums began in 1992, and the current moratorium is scheduled to run until July 1, 1999. Prior to this moratorium, the NPS had permitted use of Lake Roosevelt National Recreation Area for domestic water withdrawals for developments along the reservoir shoreline. Future applications for development of water resources across NPS land must be approved by the Washington Department of Ecology.

RECOMMENDATIONS

Water resource issues at Lake Roosevelt National Recreation Area are varied and complex. The sheer size of the watershed, the confusing jurisdictional situation, the number of demands for the water resources of Lake Roosevelt, and multiple land uses all add to this complexity. For the NPS, management of these resources and addressing the issues that threaten them is a difficult task. This difficulty stems from the multi-agency concurrent jurisdictional authority for management of Lake Roosevelt National Recreation Area's water resources, and a lack of Lake Roosevelt National Recreation Area staffing and infrastructure. Further, although some threats such as COMINCO and CELGAR seem to be easing, others will grow with continued increases in recreational use of these resources. The NPS has a vital role to play because no other agency manages more of Lake Roosevelt and its shorelines than the NPS.

In this situation, the NPS must address the issues of resource management and staffing priorities before deciding whether or not to proceed with development of a Water Resources Management Plan (WRMP). Without dedicating permanent specialized staff to water resource management, it is questionable whether or not the development of a WRMP is appropriate. This is not to say that a WRMP would not be useful at Lake Roosevelt. Rather, the considerable effort necessary to develop a WRMP would produce less return when compared to the same level of effort at other parks, where the NPS role in resource management is more straight forward and staff and resources to implement WRMP recommendations are on hand. In the absence of base support and a WRMP effort, the NPS should focus on becoming a more active participant in committees and activities related to water resource planning at Lake Roosevelt. Further, they should work proactively with the Water Resources Division (WRD) and the hydrologist at North Cascades National Park Service Complex to develop and enhance the water-related project statements in the Resource Management Plan.

If the NPS does decide to staff a water resource management program, a WRMP is recommended. This plan would attempt to facilitate multi-agency management of resources, particularly in the areas of land use, water quality, reservoir management, erosion control and fisheries/wildlife. This difficult task could be accomplished by narrowing the scope of NPS involvement in these issues, reflecting legislative limits on the role of the NPS, and acknowledging the limits of the NPS staff and infrastructure. The NPS needs to take the lead in management of other issues, including water quality as it affects recreation, recreation's effect on water quality (sewage disposal), and direct use of and impacts to NPS land, among others.

Specific recommendations include:

- 1) Obtain a solicitor's evaluation of unit mandates.
- 2) Request assistance of the Water Resources Division to develop appropriate water-related project statements for the NBA's Resource Management Plan.
- 3) Continue to develop hazard and emergency response plans.

- 4) Sign a Memorandum of Agreement with the State of Washington Department of Ecology similar to that signed by the U.S. Forest Service for water quality monitoring.
- 5) Maintain a high profile in the Lake Roosevelt Forum, and committees formed under the Lake Roosevelt Cooperative Management Agreement, including the Lake Roosevelt Water Quality Council.
- 6) Hire a full-time position in water resource management. Considering the level of complexity, the first position created should be a GS-9 or GS-11 level, capable of understanding a variety of water resource management areas. This individual could have expertise as an aquatic ecologist or hydrologist.
- 7) Conduct an inventory of water rights, uses and needs in coordination with the Water Rights Branch of the Water Resources Division and NPS's legal council (Office of the Solicitor), including the following:
 - a) Evaluate existing water rights and water withdrawal permits within Lake Roosevelt NRA and review applicable federal and state laws, in light of the 1990 agreement;
 - b) Assemble descriptive information on all wells and springs (location, depth, date developed, purpose and historical water use (e.g., Table 10) ; and
 - c) As appropriate, file for additional water rights with the Washinton Department of Ecology.

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ACKNOWLEDGMENTS

This scoping report was undertaken as a joint effort among NPS Water Resources Division, Lake Roosevelt NRA and North Cascades National Park. The authors would like to thank Mark Flora (WRD), who initiated this project through the NPS Area Hydrologists Affiliation Program and supervised development of this report. Along with Dave Sharrow (WRD), Mark also provided invaluable technical support and many reviews of draft versions. We would also like to acknowledge the staff at Lake Roosevelt NRA for their patience as we dug through their office files and library. Chief of Resources Management, Karen Taylor-Goodrich, Superintendent's Secretary, Sherry Dotson and maintenance employee, Ken Deal were particularly helpful. Finally, we would like to thank Diane Fusaro (editor) and the NPS Denver Service Center's Division of Micrographics for their production assistance.

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